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# PHYSICS ABSTRACTS

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IL 1960

Published by The Institution of Electrical Engineers

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THE INSTITUTION OF ELECTRICAL ENGINEERS, Savoy Place, London, W.C.2 © 1960
Published monthly in association with
The Physical Society, The Institute of Physics, The American Physical Society, and The American Institute of Electrical Engineers

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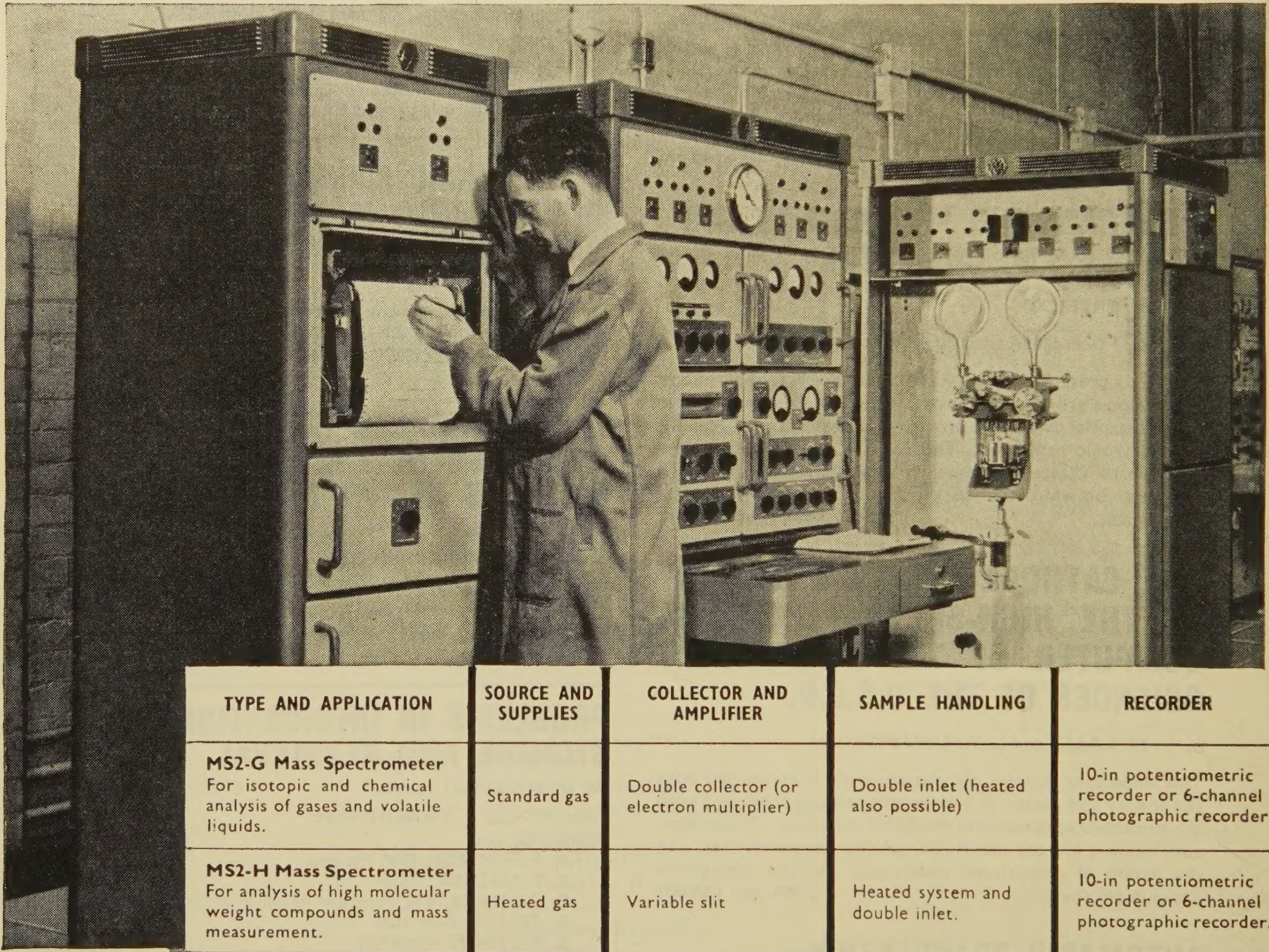

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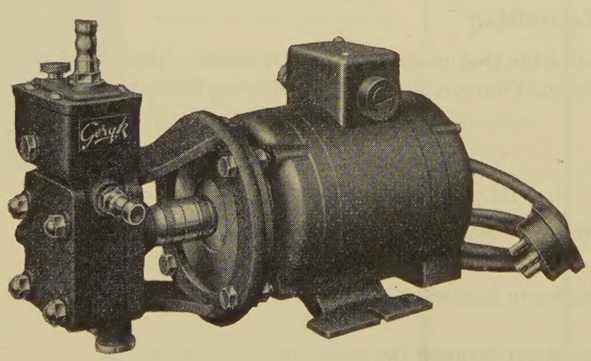

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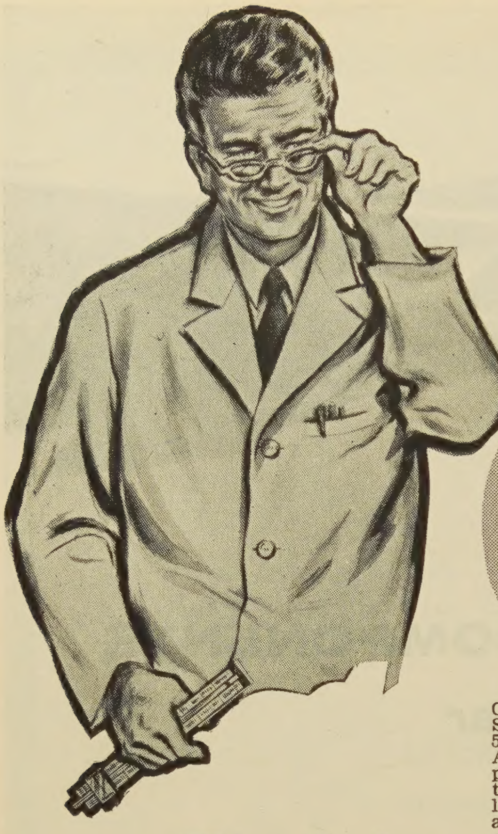

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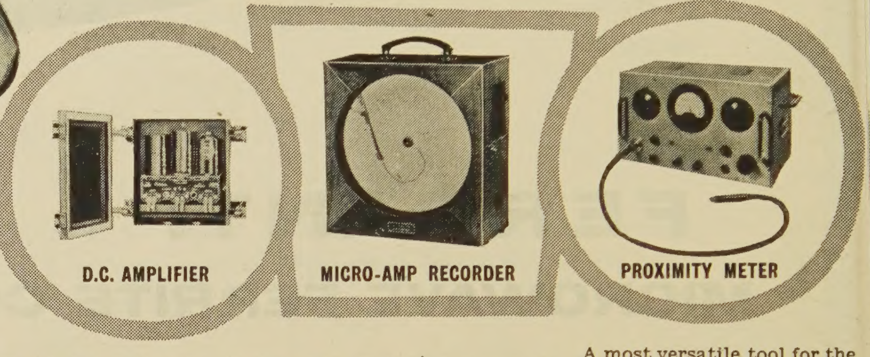

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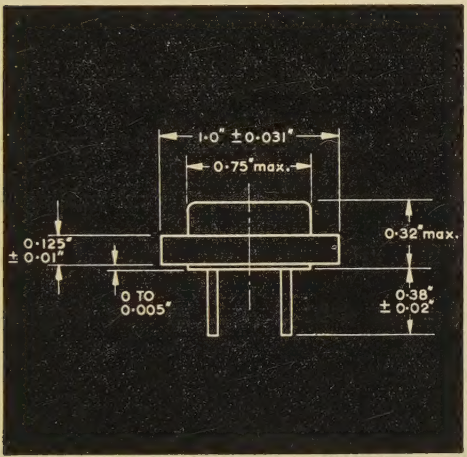

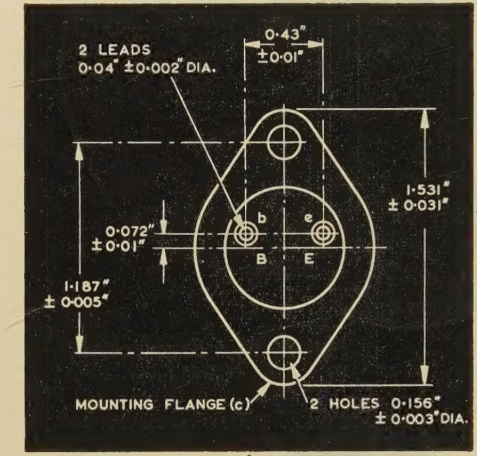

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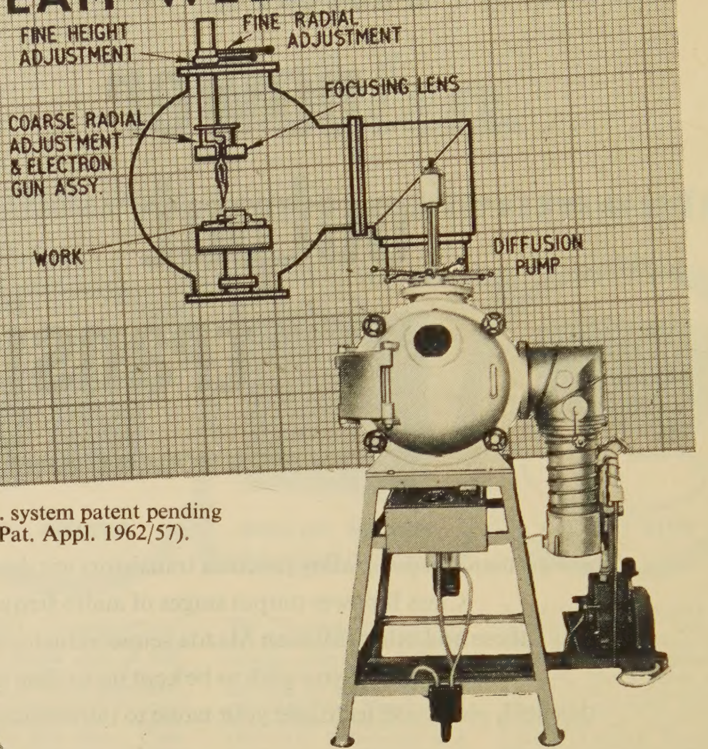

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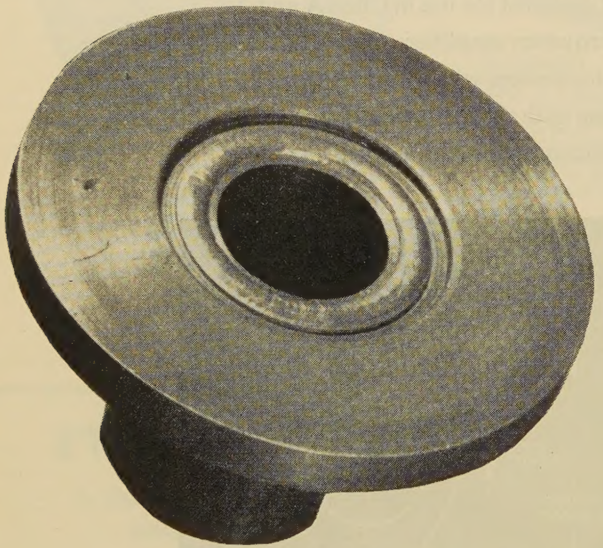

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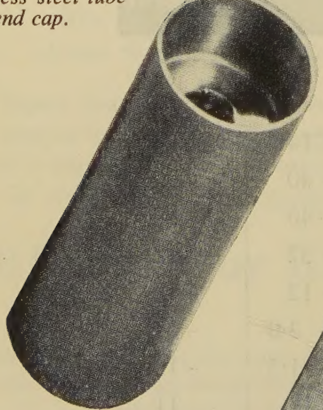

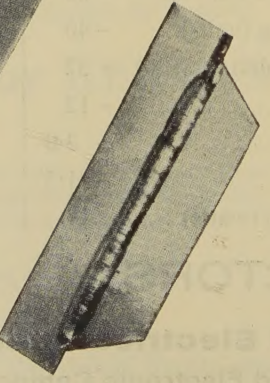

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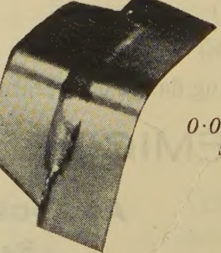

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### 3394 DEFINITION AND PROPERTIES OF THE BICUBIC SPHERICAL HARMONICS. H.Bross.

Z. Naturforsch., Vol. 14a, No. 10, 892-900 (Oct., 1959). In German.

From linear combinations of products of spherical vector functions of two pairs of variables $\theta$, $\phi$ and $\theta'$, $\phi'$ can be constructed new functions, the so-called bicubic spherical harmonics, which are invariant with respect to all pure rotations in the two spaces. Several methods are given for evaluating the coefficients in the development of these functions in terms of products of spherical vector functions $Y_{lm}(\theta,\phi)$. $Y_{l'm'}(\theta',\phi')$ and tables of numerical values for $l + l' \leq 12$ are provided. T.R.Carson

518

### 3395 ALTERNATIVE FORMS OF SOME EXPONENTIAL AND POWER FUNCTIONS FOR GRAPHICAL REPRESENTATION. C.C Harris.

J. appl. Phys., Vol. 31, No. 1, 215 (Jan., 1960).

Suppose that values $Y_r$, corresponding to equally-spaced values $X_r$ ($X_r - X_{r-1} = \Delta$) are available. Mangelsdorf (Abstr. 9129 of 1959) has suggested that the constants b and k in the formula $Y = Ae^{-bX} + k$ may be estimated from the "internal regression"

$$Y_r = Y_{r-1}e^{-b\Delta} + k(1-e^{-b\Delta})$$

In this paper the method is extended to the Rosin—Rammler and Gaudin size-distribution equations

$$Y = \exp(-bX^n) \text{ and } Y = 1-BX^n$$

respectively. N.L.Johnson

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### 3396 SOLID ANGLE SUBTENDED BY A CIRCULAR DISK. A.V.Masket.

Rev. sci. Instrum., Vol. 30, No. 10, 950 (Oct., 1959).

Summary (with references) of recent work on computation of tables of solid angles subtended by a circular disk, an aperture or a right circular cylinder. J.K.Skwirzynski

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### 3397 THE ELECTRONIC CALCULATORS AND THE CENTRE OF STUDIES ON ELECTRONIC CALCULATORS AT PISA. M.Conversi.

Nuovo Cimento Suppl., Vol. 11, No. 3, 376-96 (1959). In Italian.

The basis of operation of electronic digital computers is explained by analogy with small mechanical calculating machines. The principal characteristics of the input, output, control, arithmetical and memory units are discussed and the performances of a number of large machines now in operation or under construction are tabulated. The number and organization of the mathematical staff associated with the machines is considered with special reference to the organization at the centre of studies at Pisa. Details of a small machine in operation at the centre and of the large machine (CEUP) due to operate in 1960 are given. CEUP can operate with either fixed or floating point, has an addition time of 20 $\mu$s, a multiplication time of 230 $\mu$s and a memory of $3 \times 10^4$ words of 36 binary digits. R.D.Smith

518

### 3398 THE CRITERIA OF LOGICAL DESIGN OF THE ELECTRONIC CALCULATOR OF THE CENTRE OF STUDIES ON ELECTRONIC CALCULATORS AT PISA. A.Caracciolo and E.Fabri.

Nuovo Cimento Suppl., Vol. 11, No. 3, 397-404 (1959). In Italian.

The design of a digital computer considered as a series of units (input, output, memory, arithmetical unit, etc.) connected in a logical manner is outlined. The most efficient arrangement depends on the field of application of the machine. The machines at Pisa are designed for scientific research work. The objectives were to build a machine fast and flexible in operation, that could easily be modified or increased in size and using a type of instruction that would minimize the work of programming. A small machine was constructed to demonstrate the principles of the final machine. These include the use of the binary system, parallel operation in which all 36 digits of a word can be transferred simultaneously, use of voltage levels rather than pulses for transferring information, delayed registers in which the information is stored in short memory circuits before being printed out, and a system of routing instructions to one address only, allowing automatic modification of instructions as the calculation proceeds. R.D.Smith

518

### 3399 EQUIPMENT FOR MEASURING THE ONE-DIMENSIONAL DIFFERENTIAL AND INTEGRAL DISTRIBUTION LAWS OF CHANCE QUANTITIES. V.V.Chilikin.

Pribory i Tekh. Eksper., 1959, No. 3, 67-71 (May-June). In Russian.

The equipment described (PVM) is based on the principle of periodically comparing a chance voltage with a fixed analysis level, and is designed for positive chance input voltages of 15 to 150 V and fixed positive analysis from 0 to 15 V. External triggering is by 1 $\mu$sec positive pulses of not less than 50 V, with repetition rate adjustable from 0.3 to 10 kc/s. Accuracies are ± 4% and ± 8% for integral and differential distribution laws respectively. A sketch shows the voltages at various points of the circuit diagram. D.E.Brown

518 : 537.533

PROBABILITY DENSITY MEASUREMENT WITH AN ELECTRODE MOUNTED IN THE FACE OF A CATHODE-RAY TUBE. See Abstr. 2386

518.5 : 538.56 : 681.142

ANALOGUE INTEGRATOR FOR E.P.R. SPECTRA. See Abstr. 2454

519

### 3400 DETERMINATION OF THE MEAN ERROR BY MEANS OF THE REFINEMENT OF THE RESULTS OF OBSERVATIONS. F.Halmos.

Acta tech. Hungar., Vol. 23, No. 4, 341-55 (1959). In German.

If data are arranged, e.g. by grouping, in different patterns, different estimates of standard deviation are obtained. Some numerical results are given. N.L.Johnson

519

### 3401 FIRST-ORDER STOCHASTIC PROCESSES. I.M.Krieger and P.J.Gans.

J. chem. Phys., Vol. 32, No. 1, 247-51 (Jan., 1960).

A general class of "first-order" stochastic processes is defined as those for which the probability per unit time of a transition out of a state is proportional to the occupancy of that state. The solution to the differential-difference equation for the process, obtained earlier by Siegert (Abstr. 2253 of 1950), is obtained here using more elementary mathematics. The resultant solution is used to demonstrate that a system relaxing by first-order processes from one equilibrium state to another will maintain, at all times, a multinomial distribution.

# ASTROPHYSICS

522

### 3402 ALUMINIZING TECHNIQUE AND THE ULTRAVIOLET EFFICIENCY OF TELESCOPES.

W.M.Sinton, H.L.Johnson and K.L.Hallam.

Publ. Astron. Soc. Pacific, Vol. 71, 239-40 (June, 1959).

The reflectivity of aluminium in the ultraviolet is known to be higher if the evaporation is carried out with a high vacuum and short deposition time. The Lowell 42-inch telescope mirrors have been re-aluminized to correct ultraviolet deficiencies of previous coatings. An aluminium getter was used to reduce the pressure immediately before coating and a deposition time of 20 seconds was achieved at a low pressure. The three mirror telescope shows a considerable gain in the ultraviolet. R.W.Fish

523.11

### 3403 STELLAR ATMOSPHERES AS A PLASMA.

L.Biermann.

Nuovo Cimento Suppl., Vol. 13, No. 1, 189-200 (1959).

The basic equations for a two-fluid plasma are given, and these are considered in relation to the transport of radiation through the opaque and transparent layers of the sun. A survey is given of current theories on the subjects of sunspots, ionization in the solar corona, and the rotation of interplanetary gas. A number of models for comet tails are described. A.H.Gabriel

523.11

### 3404 THE INTERSTELLAR PLASMA.

H.C.van de Hulst.

Nuovo Cimento Suppl., Vol. 13, No. 1, 205-32 (1959).

Observations on the distribution of matter and velocity in the galaxy are described. The possibility of synchrotron radiation being the main source of light and radio waves is considered, particularly with regard to the Crab nebula. The presence of magnetic fields in interstellar space is considered in the light of current theories of force free fields. A.H.Gabriel

523.12

### 3405 THE STEADY-STATE UNIVERSE AND THE DEDUCTION OF CONTINUAL CREATION OF MATTER.

V.A.Bailey; H.Bondi.

Nature (London), Vol. 184, 537, 537-8 (Aug. 15, 1959).

The deduction of continuous creation from the perfect cosmological principle is dependent upon the assumption that the universe is describable in terms of a four-dimensional space-time $U_4$. [See Bondi and Gold, Monthly Not. Roy. Astron. Soc., Vol. 108, 252 (1948); Bondi, "Cosmology", Cambridge University Press (1952)]. It is suggested that it may be possible to reformulate the theory, regarding $U_4$ as a hyper-surface in a 5-space $U_5$, with the conservation laws satisfied in $U_5$. Bondi in a following note draws attention to a paper by himself and Lyttleton (see following abstract).

R.A.Newing

523.12

### 3406 ON THE PHYSICAL CONSEQUENCES OF A GENERAL EXCESS OF CHARGE. R.A.Lyttleton and H.Bondi.

Proc. Roy. Soc. A, Vol. 252, 313-33 (Sept. 29, 1959).

The possibility of a general excess of charge in the universe is proposed. If such exists, even to the extent of only 2 parts in $10^{18}$, sufficiently powerful electric forces result to produce the observed expansion of the universe on the basis of Newtonian mechanics. If the excess occurs as a slight difference in magnitude of the proton and electron charges, the hypothesis may be on the verge of what could be established by experiment. If creation of matter, and also necessarily charge, is assumed, the Maxwell equations must be modified to avoid strict conservation. The appropriate modification is shown to involve additional terms in the current and charge-density equations proportional to the vector and scalar potentials. When applied to a spherically symmetrical smoothed-out universe, the revised equations establish almost rigorously that electrical requirements imply a strict velocity-distance law for the mass motion of expansion. For agreement with observation, the requisite charge on the proton would be $(1 + y)e$ where $y \cong 2 \times 10^{-18}$, or, if the charges are strictly equal in magnitude, it requires $1 + y$ protons for every electron, with the same value of $y$. The value of the Hubble constant and of the smoothed-out density of matter in the universe are shown to be simply related by the theory to the rate of creation. The same solution is shown to hold equally in de Sitter space-time, and the principle of complete equivalence of all observe at all times is thereby demonstrated to be a property of the solution. Construction of the corresponding stress-energy tensor enables the factor associated with the new terms in the Maxwell equations to be directly related to the observable radius of the universe. On the first form of the charge-excess hypothesis, galaxies and clusters of galaxies (with their haloes) arise as ionized condensation units within the general background distribution. Since the units are conducting, they remain electrically neutral, and therefore grow and are controlled by ordinary gravitational forces. Moreover, because they are conducting, the units will expel their excess charge in the form of free protons. It is shown that the electrostatic potential at the surface of a unit is maintained by creation at such a value that the protons are expelled with energies corresponding to the highest energy cosmic rays. These units will take part in the general expansion, not under the direct action of the electric repulsion, but because they form and grow from the expanding background material. Any small departure in velocity of a unit from the local value would be quickly removed through the gravitational braking action associated with accretion of further material. The gravitational potential at the surface of a unit is such that infalling hydrogen atoms will have energy of motion corresponding to temperature of the order of a million degrees, and the outer parts of the units at least will be at high temperature.

523.16

### 3407 ON THE CORRELATION OF SOLAR NOISE FLUCTUATIONS IN HARMONICALLY RELATED BANDS.

L.R.O.Storey.

J. Res. Nat. Bur. Stand., Vol. 63D, No. 3, 293-6 (Nov.-Dec., 1959).

A method is proposed for the study of the solar corona, by observing a delayed correlation between rapid fluctuations of enhanced solar radio emission in harmonically related frequency bands. The correlation is expected in those types of emission that are produced by nonlinear plasma oscillations. The delay of the fundamental frequency with respect to the harmonic would be brought about by dispersive group retardation in the corona. The method appears to be most suitable for use with type II bursts, though it might also be applied to other types of nonthermal solar emission.

523.16

### 3408 SOLAR DISTURBANCES PRODUCING TYPE II RADIO BURSTS. R.G.Giovanelli.

Nuovo Cimento Suppl., Vol. 13, No. 1, 299-301 (1959).

Streams of particles passing through the corona excite plasma oscillations. By studying the harmonics emitted, some evidence can be found of considerable departures from spherical symmetry in the corona. A.H.Gabriel

523.16

### 3409 THE IDENTIFICATION OF RADIO STARS.

A.M.Naqvi and J.N.Tandon.

Proc. Nat. Inst. Sci. India A, Vol. 21, No. 4, 244-51 (July 26, 1955).

A comparison of the position of the radio stars with M dwarf stars, lying within the limits of declination $-25^\circ$ and $+60^\circ$, has been made. 41 M dwarfs lie within the range of probable error of 28 radio stars. Further 20 M dwarfs lie within the range of probable error of the other coordinate of 17 radio stars. The distance of radio stars calculated with an assumption that M dwarfs are mainly responsible for the radio flux from Andromeda nebula, is in agreement with the distance of the M dwarfs. The other types of stars such as T—Tauri stars, metallic line stars, flare stars, the bright H and K emission stars do not show any significant coincidences.

523.2

### 3410 MAGNETIC FIELD IN THE SOLAR SYSTEM.

T.Gold.

Nuovo Cimento Suppl., Vol. 13, No. 1, 318-23 (1959).

It is shown that weakly magnetized plasma can be ejected from the sun, and will travel considerable distances before being restrained by the magnetic field. If the earth comes within such a magnetic loop from the sun, a decrease in non-solar cosmic radiation is observed, followed by increased solar particle flux.

A.H.Gabriel

523.4

### 3411 THE COLORS OF JUPITER.

H.A.Papazian.

Publ. Astron. Soc. Pacific, Vol. 71, 237-9 (June, 1959).

To account for the coloured band features seen on the planet it is proposed that these are caused by charged particle bombardment of normally colourless atmospheric condensates. The particles are supposedly of solar origin, and are trapped by a planetary magnetic field. To provide for the observed colour belts, three separate Van Allen type radiation zones are envisaged, each giving an intense bombardment at the required Jovian latitude. The polar regions will remain permanently coloured by continuous inflow of untrapped particles spiralling inward along the planetary lines of force. If the above hypothesis is correct a correlation of colour changes in the Jovian atmosphere with solar activity in the 11 year cycle may be expected. This is borne out by observations during recent sunspot cycles. D.R.Barber

523.5

### 3412 NEW DATA ON TECTITES.

G.G.Vorob'ev.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 1, 61-2 (Sept. 1, 1959). In Russian.

A description of small globules of magnetic material which have been discovered on or near the surfaces of certain forms of rizalites (tectites from the Philippines). Their diameters are usually in the range 1.5-2 mm. They can be explained as due to collisions and subsequent fusion of the tectitic material. G.A.Chisnall

523.5

### 3413 CALCULATION OF A "COSMIC RAY AGE" FOR THE IRON METEORITE "CARBO". R.R.Marshall.

Nature (London), Vol. 184, 117-18 (July 11, 1959).

A determination of the age by the potassium produced by spallation yields a value of $0.6_9 \times 10^9$ years. The difficulty of estimating the production cross-section for potassium isotopes is discussed. J.M.Hough

523.5

### 3414 THE SPECTRUM OF THE ZODIACAL LIGHT.

J.M.Beckers.

Proc. K. Ned. Akad. Wetensch. B, Vol. 62, No. 4, 248-62 (1959).

From a critical discussion of Hoffmeister's spectrograms obtained in S.Africa (Abstr. 695 of 1940) it appears that the presence of the Ca II H, K lines points to sunlight scattered by stationary dust and electrons as the origin of the zodiacal light. However, neither the known temperature distribution in interplanetary space, nor the estimated degree of electron scatter derived from polarization observations of the zodiacal light fit the above interpretation. With the present imperfect knowledge of the nature of the zodiacal light the results of spectrographic and polarization observations must remain incompatible. D.R.Barber

523.6 : 537.56

### 3415 FORMATION OF $CO^+$ IONS IN COMETS.

L.Biermann and E.Trefftz.

Z. Astrophys., Vol. 49, No. 2, 111-18 (1960).

$CO^+$ ions in comets are presumably formed from CO molecules by charge exchange with solar protons. By this process only a little momentum is transferred from the protons to the $CO^+$ ions, the average velocity of $CO^+$ being smaller than 1 km/sec. There might be a small fraction of charge exchange impacts with appreciable momentum transfer. The cross-section for forming $CO^+$ ions with more than about 10 km/sec initial velocity is estimated. It is concluded, therefore, that charge-exchange processes with high momentum transfer will not be responsible for the velocities of $CO^+$ ions observed in comet tails.

523.7

### 3416 THE OBSERVABILITY OF HYDROMAGNETIC PHENOMENA ON THE SUN. K.O.Kiepenheuer.

Nuovo Cimento Suppl., Vol. 13, No. 1, 305-10 (1959).

Diagnostic information is limited by the restrictions of current observational techniques. Further measurements are required in particular of the temporal changes in solar phenomena, and of their magnetic field structures. A.H.Gabriel

523.74

### 3417 OPTICAL AND RADIOPHENOMENA ASSOCIATED WITH A SOLAR ACTIVITY CENTRE. C.De Jager.

Nuovo Cimento Suppl., Vol. 13, No. 1, 284-90 (1959).

Presents a survey of the current understanding of activity centres. It is shown that temperatures of the order of $10^7$ °K can be produced in solar flares. A.H.Gabriel

523.74

### 3418 DYNAMICAL FEATURES OF THE CHROMOSPHERE.

C.De Jager.

Nuovo Cimento Suppl., Vol. 13, No. 1, 291-8 (1959).

The structure of the solar chromosphere is considered with particular reference to its temperature. It is shown that a stable system could be composed of two types of gas at temperatures of 6000°K and 20 000°K respectively. This is associated with the origins of "spicules", upward projections of the chromosphere into the corona region. The flux of turbulent motion from the photosphere plays an important part in the heating. A.H.Gabriel

523.74

### 3419 FLARE SURGES, PUFFS AND TYPE III BURSTS.

R.G.Giovanelli.

Nuovo Cimento Suppl., Vol. 13, No. 1, 302-4 (1959).

Experimental evidence for correlation between these solar phenomena is reviewed. A.H.Gabriel

523.74

### 3420 STRUCTURE OF THE PERTURBED SOLAR ATMOSPHERE. K.O.Kiepenheuer.

Z. Astrophys., Vol. 49, No. 2, 73-94 (1960). In German.

The observation of thread-shaped loops in the photosphere is reported (length $<\sim$ 8000 km, thickness $<\sim$ 1500 km). They occur mainly in the vicinity of spots showing strong changes of their magnetic field. The chromospheric structures in a centre of activity are reduced to the following basic components, which together form the well-known vortex structure: dark elongated structures ($\sim 1500 \times 4000$ km) visible only in the wing of H$\alpha$, probably to be identified with spicules, arranged in the form of hedges; long threads, visible only in H$\alpha$ (length 20 000 to 100 000 km, thickness $<\sim$ 1000 km) thickness $<\sim$ 1000 km), which connect spots of opposite polarity, or a spot with its surrounding, or two points outside the spots, the points of intersection always falling on the hedges; some threads in the form of loops; bright dots (diameter in H$\alpha$ $<$ 1500 km, in K3 $<\sim$ 2500 km); bright regions in H$\alpha$ and $K_2$ with dimensions $>$ 5000 km in the very vicinity of spots. The observed photospheric and chromospheric threads and loops are interpreted as flux tubes of the deep-seated magnetic field, which have penetrated the photospheric granulation outside the sunspots.

523.74

### 3421 SOLAR ACTIVITY IN 1958.

T.A.Cragg.

Publ. Astron. Soc. Pacific, Vol. 71, 212-15 (June, 1959).

The very high total of 910 sunspot groups observed at Mt. Wilson, U.S.A., during the year (with a provisional Zurich number of 200.5) established the present sunspot cycle as the most active ever recorded. D.R.Barber

523.75

### 3422 THE PRINCIPAL SOURCE OF SOLAR CORPUSCULAR STREAMS. E.R.Mustel'.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 2, 265-8 (Sept. 11, 1959). In Russian.

Detailed reasons are given for supposing the magnetic field in a floccula to be the fundamental factor governing the ejection of corpuscles in approximately radial streams. The efflux of corpuscles seems to be independent of the presence or absence of spots in the flocculi. The energy of gaseous condensations in the corpuscular streams may be mainly magnetic rather than kinetic in origin. G.A.Chisnall

523.8

### 3423 MOTIONS IN STELLAR ATMOSPHERES.

P.W.Merrill.

Publ. Astron. Soc. Pacific, Vol. 71, 292-300 (Aug., 1959).

Motions of radiation and matter in stellar atmospheres are classified and qualitatively reviewed. R.W.Nicholls

523.87 : 539.17

### 3424 NUCLEAR REACTIONS IN STARS. IV. BUILDUP FROM CARBON. H.Reeves and E.E.Salpeter.

Phys. Rev., Vol. 116, No. 6, 1505-16 (Dec. 15, 1959).

For previous work see Abstr. 588 (1953); 2594 (1958). Reaction leading to the formation of C, O, and Ne at temperatures T of about $10^8$ °K, in the core of red giant stars, have been studied previously. The nuclear reactions and resulting nucleogenesis are now studied for a gas consisting of $C^{12}$, $O^{16}$ and $Ne^{20}$ at $6 \times 10^8$ to $10 \times 10^8$ °K and densities around $10^4$ g cm$^3$. The basic reaction rates are calculated and a set of simultaneous differential equations for various abundances as a function of time is solved numerically. The $C^{12}$ is destroyed by compound nucleus formation from C + C collisions in about $10^5$ and 1 years, respectively, at $6 \times 10^8$ and $8.5 \times 10^8$ °K. The net result is the production of some additional amounts of $O^{16}$ and $Ne^{20}$; appreciable amounts of $Na^{23}$ and the three stable magnesium isotopes (mainly $Mg^{24}$) and decreasing amounts of $Al^{27}$, Si, etc. The ratio of $Na^{23}$ to $Mg^{24}$ produced is almost $\frac{1}{2}$, appreciably larger than the "cosmic" ratio. During the carbon burning, protons and alphas are released. At temperatures below $7 \times 10^8$ °K, neutrons are produced very copiously through the sequence $C^{12}(p,\gamma)N^{13}$; $N^{13} \rightarrow C^{13}$; $C^{13}(\alpha,n)O^{16}$. If small amounts of metals in the Fe-region (up to about one metal nucleus per 1000 $C^{12}$ nuclei) were present originally, each metal nucleus will absorb about 30 neutrons. At temperatures above $8 \times 10^8$ °K, $N^{13}$ is photodisintegrated and the neutron production is appreciably less.

525

### 3425 OBSERVATIONS ON SOMIGLIANA'S FORMULA FOR THE GRAVITATIONAL FIELD. G.Boaga.

Ann. Geofis., Vol. 12, No. 2, 155-9 (1959). In Italian.

The formula permits the calculation of the degree of flattening of the earth's figure from observations of gravity at three different latitudes. Attention is drawn to the sensitivity of the result with respect to local gravitational anomalies. R.A.Newing

525 : 530.12

### 3426 GRAPHICAL DERIVATION OF THE INVERSE-SQUARE LAW OF GRAVITATION FROM AN ELLIPTIC ORBIT AND KEPLER'S LAW OF AREAS. A.V.Baez.

Amer. J. Phys., Vol. 28, No. 3, 254-9 (March, 1960).

Motivated by the common knowledge that earth satellites move in elliptic paths, a graphical demonstration is presented which shows that if a small mass moves in an elliptic orbit about a large mass at one focus and obeys Kepler's law of areas, the force of attraction on it must vary inversely as the square of the distance between the two masses. The demonstration differs from the usual elementary proofs of the inverse-square law in that it assumes elliptic rather than circular orbits, uses the law of areas instead of the dependence of period on semi-major axis, and requires a minimum of formal mathematics. By using a similar construction it may be shown tha if the large mass is at the centre of the ellipse, the force varies linearly with distance.

52

### 3427 NEW METHOD OF SOLUTION FOR UNRETARDED SATELLITE ORBITS. J.P.Vinti.

J. Res. Nat. Bur. Stand., Vol. 63B, No. 2, 105-16 (Oct.-Dec., 1959).

An axially symmetric solution of Laplace's equation in oblate spheroidal coordinates is found, which may be used as the gravitational potential about an oblate planet. This potential, which makes the Hamiltonian–Jacobi equation for a satellite orbit separable, ha an expansion in zonal harmonics in which the amplitudes of the zeroth and second harmonics can be adjusted to agree exactly with the values for any axially symmetric planet and a fourth harmonic which then agrees approximately with the latest value for that of th earth. The net result is therefore a reduction of the problem of satellite motion to quadratures, with use of a potential field that is much closer to the empirically accepted one for the earth than any heretofore used as the starting point of a calculation. It may thus be possible to do the gravitational theory of a satellite orbit very accurately without use of perturbation theory. The method can tak into account a first harmonic in the potential, in case observations are reduced to a centre which does not coincide with the centre of mass of the planet.

525 : 551.

MASS-SPECTROMETRIC MEASUREMENTS OF THE IONIC STATE OF THE UPPER ATMOSPHERE BY THE THIRD ARTIFICI SPUTNIK. See Abstr. 3342

:2

### 3428 OBSERVATIONS OF THE RUSSIAN MOON ROCKET LUNIK II.

J.G.Davies and A.C.B. Lovell; P. Moore; H.P.Wilkins.

Nature (London), Vol. 184, 501-2, 502, 502 (Aug. 15, 1959).

Radio observations at Jodrell Bank on frequencies of 183.6 and 19.992 Mc s confirmed that the Russian rocket hit the moon within 7 minutes of arc from the centre of the disk at 21 h 02 m 23 s U.T on Sept. 13, 1959. Independent visual observations by Moore and by Wilkins indicated a small pinpoint of light in the same region of the lunar surface at the same time, which may have represented the impact. G.M.Brow

# PHYSICS

## GENERAL

53

### 3429 VISITING FOREIGN STAFF PROJECT (V.F.S.P.) AT TEMPLE UNIVERSITY. E.L.Offenbacher.

Amer. J. Phys., Vol. 28, No. 3, 173-8 (March, 1960).

53

### 3430 ON THE EDUCATION OF PHYSICISTS IN THREE FOREIGN COUNTRIES. A.M.Goldfarb.

Amer. J. Phys., Vol. 28, No. 3, 179-86 (March, 1960).

The basic system of education in France, Argentina, and England are described, each followed by a discussion of the training of a future physicist or physics teacher in that country.

53

### 3431 NATURE OF PHYSICS AND ITS RELATION TO OTHER DISCIPLINES. G.P.Thomson.

Amer. J. Phys., Vol. 28, No. 3, 187-92 (March, 1960).

Physics is one aspect of the science which deals with nonliving matter. It is concerned primarily with general principles valid either for all kinds of material, as for example gravitation, or relating to laws in which matter as such does not come in directly; for example, the propagation of electromagnetic waves in a vacuum. However, the boundary between physics and chemistry in common parlance is largely historical in origin. Physics is a great triumph of the human mind, but it has often grown from the study of apparent trivialities. That these can lead to the most important discoveries is itself one of the great discoveries of the scientific method. Ther is as yet no all-embracing physical theory, and as knowledge increases the significance of the partial theories is seen to change, but they are seldom entirely superseded. Even a successful universal theory would leave much to do; the consequences of theories are deemed worthy or unworthy of study for aesthetic or practical reasons. Nature is no longer considered to be deterministic in detail though it is in gross. The practical value of physics showed itself clearly in the development of electrical engineering, and new physics has become essential to a developing civilization. Scientists are responsible for those consequences of their actions which reasonably can be foreseen, but the extent to which consequences can be foreseen is exaggerated. The different parts of a civilization are interlocked and it must be accepted or rejected as a whole.

53

### 3432 TEN YEARS' DEVELOPMENT OF PHYSICS IN CHINA.

Scientia Sinica, Vol. 8, No. 10, 1120-30 (Oct., 1959).

53

### 3433 SPACE RESEARCH.

H.S.W.Massey.

Contemporary Physics, Vol. 1, No. 2, 81-95 (Dec., 1959).

A review article which outlines the nature of space research, the technical problems involved, and the range of scientific investigations which may be carried out. These are: (1) Study of the high atmosphere of the earth. (2) Meteorological studies. (3) Study of the gravitational and magnetic fields of the earth. (4) Astronomical observations from outside the atmosphere. (5) Study of particle radiations in interplanetary space. (6) Study of the composition and nature of the matter in interplanetary space including micrometeoric dust, neutral and ionized atoms and electrons. (7) Studies of the moon and planets in situ. (8) Investigation of the nature of gravitation. A short review is given of each one. The practical applications of space research are discussed, and its international character pointed out.

53

3434 THE PHYSICAL SOCIETY'S EXHIBITION — LONDON, 1959. R.V.Jones.

J. sci. Instrum., Vol. 36, No. 5, 201-5 (May, 1959).

A general survey is given of the newer developments of instruments and apparatus exhibited, together with some observations on the Exhibition.

53

3435 THE HALF-PLANE DIFFRACTION PROBLEM FOR HARMONIC TIME DEPENDENCE. A.P.Burger.

Proc. Roy. Soc. A, Vol. 252, 411-17 (Sept. 29, 1959).

Green's functions are obtained for the boundary-value problems of mixed type describing the general two-dimensional diffraction problems at a screen in the form of a half-plane (Sommerfeld's problem), applicable to acoustically rigid or soft screens, and to the full electromagnetic field at a perfectly conducting screen.

53 : 551.5

3436 SINGLE PEN, STRIP CHART RECORDER FOR UNATTENDED LONG PERIOD OPERATION.

C.J.Sumner.

J. sci. Instrum., Vol. 36, No. 11, 475-7 (Nov., 1959).

A battery operated recorder is described which is designed for operation for periods of 6 to 12 months without attention. It is suitable for recording such elements as water depth, rainfall, temperature, etc., and is provided with a solar time-check device which obviates the need for an expensive precision clock. Recording is by a needle-pointed stylus which perforates the chart paper when depressed by a chopper bar. A relatively simple linkage is used to give a rectilinear traverse to the stylus.

## GRAVITATION . RELATIVITY

530.12

3437 GENERALIZATION OF THE EINSTEIN EQUATIONS CORRESPONDING TO A NON-ZERO MASS FOR THE GRAVITON. P.Droz-Vincent.

C.R. Acad. Sci., (Paris), Vol. 249, No. 22, 2290-2 (Nov. 30, 1959). In French.

The analogy between gravitation and electromagnetism is obtained by the introduction of a symmetrical potential $A^{\mu\nu}$. The formalism thus developed permits the generalization of the Einstein equations by the addition of a term which corresponds to the mass of the graviton. T.R.Carson

530.12

3438 SOME GRAVITATIONAL WAVES. A.Peres.

Phys. Rev. Letters, Vol. 3, No. 12, 571-2 (Dec. 15, 1959).

By considering the metric

$$ds^2 = -dx^2 - dy^2 - dz^2 + dt^2 - 2f(x, y, z+t)(dz+dt)^2$$

a new class of solutions of the Einstein gravitational equations is derived. Some particular cases of the function f are briefly examined. T.R.Carson

530.12

3439 THE GRAVITATIONAL FIELD OF A PARTICLE POSSESSING A MULTIPOLE MOMENT.

G.Erez and N.Rosen.

Bull. Res. Coun. Israel, Vol. 8F, No. 1, 47-50 (Sept., 1959).

Using the method of Weyl and Levi-Civita, a procedure is proposed for calculating the metric tensor describing the gravitational field of a particle possessing a mass multipole moment. Calculations are carried out for the case of a quadrupole moment.

530.12 : 525

GRAPHICAL DERIVATION OF THE INVERSE-SQUARE LAW OF GRAVITATION FROM AN ELLIPTIC ORBIT AND KEPLER'S LAW OF AREAS. See Abstr. 3426

530.12

3440 THE PROBLEM OF THE ENERGY OF THE GRAVITATIONAL FIELD. H.G.Schöpf.

Ann. Phys. (Leipzig), Folge 7, Vol. 5, No. 1-2, 1-3 (1959). In German.

A metric is introduced corresponding to standing waves within a circular cylinder, the cylinder being embedded in flat space—time. It is argued that the total energy of the field is zero independently of any assumed form for the pseudo-tensor $t^{\nu}{}_{\mu}$. R.A.Newing

530.12 : 539.12

ON THE QUESTION OF ANTIGRAVITATION. See Abstr. 2503

530.12

3441 RIGID FRAMES IN RELATIVITY. E.T.Newman and A.I.Janis.

Phys. Rev., Vol. 116, No. 6, 1610-14 (Dec. 15, 1959).

A new approach is presented for defining and obtaining rigid frames of reference. The results are shown to be equivalent to those of Rosen (Abstr. 1121 of 1954). The advantage of the present approach is that exact solutions can be obtained in certain simple cases, as well as approximate solutions in general.

530.12

3442 CLASSICAL PROPERTIES AND BILOCAL REPRESENTATION OF THE ROTATOR OF NAKANO.

L.de Broglie, P.Hillion and J.P.Vigier.

C. R. Acad Sci. (Paris), Vol. 249, No. 22, 2255-8 (Nov.30, 1959). In French.

Some of the consequences of substituting a relativistic rotator for a dimensionless particle as the classical basis of the theory of quanta are examined. In particular, the Nakano model shows very interesting properties. T.R.Carson

530.12

3443 THE CLASSICAL MOTION OF THE RELATIVISTIC ROTATOR. F.Halbwachs.

C.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2293-5 (Nov. 30, 1959). In French.

530.12

3444 STATIONARY ROTATION OF A COSMIC GASEOUS MASS IN THE GENERAL THEORY OF RELATIVITY.

Yu.P.Chernov.

Dokl. Akad. Nauk SSSR, Vol. 129, No. 4, 762-5 (Dec. 1, 1959). In Russian.

A gaseous mass fills the whole space and revolves about an axis in its own gravitational field; the rotation is assumed to be adiabatic. The gravitational Einstein equations are solved by the method of successive approximations in a cartesian system of coordinates. Expressions for the n-th approximations (i.e. expansions in small parameter $c^{-1}$) of the metric tensor components, of pressure and angular velocity, are obtained for a given value of the rest mass density. J.K.Skwirzynski

530.12 : 539.3

3445 A THEORY OF ELASTICITY IN GENERAL RELATIVITY. J.L.Synge.

Math. Z., Vol. 72, 82-7 (1959).

The theory of elasticity in a gravitating medium is based on a modified Hooke's law "rate of change of stress is a linear function of rate of strain", and is developed for the isotropic case involving two invariant elastic coefficients $\lambda$ and $\mu$. It is shown that elastic waves are propagated relative to the material with speeds which are formally the same as those for longitudinal and transverse waves in classical theory. R.A.Newing

530.12

3446 ON THE METHOD OF SINGULARITIES IN THE JORDAN—THIRY 5-DIMENSIONAL THEORY. A.Surin.

C.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2279-81 (Nov. 30, 1959). In French.

The extension of the Einstein—Infeld—Hoffmann method to 5-space is considered, and the equations of motion are determined in the first approximation in the case of a spherically symmetric field with N point-singularities. R.A.Newing

530.12

3447 REMARKS ON THE IDENTITIES RELATING TO A LAGRANGIAN. J.Géhéniau.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 45, No. 5, 447-50 (1959). In French.

The identities relating to a Lagragian which depend on functions of their first and second derivatives are put in new forms. The variances of the quantities appearing are indicated. One obtains thus, in the case where the Lagrangian is the density of Gaussian curvature, the pseudo-tensors introduced by Møller in general relativity. T.R.Carson

## QUANTUM THEORY

*(Applications of quantum theory to elementary particles and nuclei are included under Nuclear Field Theory)*

530.14

3448 SOME RECENT DEVELOPMENTS IN THE MANY-BODY PROBLEM. D.ter Haar.
Contemporary Physics, Vol. 1, No. 2, 112-33 (Dec., 1959).

A brief account is given of the reasons why the many-body problem has recently become the subject of a rapidly expanding literature. After a survey of the main ideas of recent theories, it is shown how these have played a role in giving a better understanding of such topics as superconductivity, plasmas, and liquid helium. In the theory of the many-body problem the main branches of theoretical physics applied are Hamiltonian mechanics or quantum mechanics (to describe the motion of the constituent particles of the many-body system under consideration) and statistical mechanics (to describe the collective action of the large number of particles in the system). The main concepts of Hamiltonian mechanics and some of those of quantum statistics are discussed in an appendix, including the definition and some of the properties of fermions and bosons.

530.14

3449 THE ALGEBRA OF MICROSCOPIC MEASUREMENT. J.Schwinger.
Proc. Nat. Acad. Sci. U.S.A., Vol. 45, No. 10, 1542-53 (Oct., 1959).

An algebra of "measurement symbols" is developed to express the philosophy of observations which alter the observed system. The algebra is used to demonstrate in a very general way the connection between operators and observables, and some properties of matrix representations. Any final detailed development of quantum dynamics must be consistent with this "measurement algebra". J.Hawgood

530.14

3450 PLANE ROTATOR IN A STARK FIELD. M.Schwartz and M.Martin.
Amer. J. Phys., Vol. 26, No. 9, 639-40 (Dec., 1958).

Can be used to illustrate many aspects of quantum mechanics because of the simplicity of its solutions.

530.14

3451 QUANTIZATION OF THE MOTION OF THE NAKANO ROTATOR. P.Leruste.
C.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2296-7 (Nov. 30, 1959). In French.

Quantization of the motion of the Nakano rotator, moving in an electromagnetic field, leads to the equation of Feynman and Gell-Mann. T.R.Carson

530.14

3452 IN–OUT FORMALISM FOR NONRELATIVISTIC QUANTUM MECHANICS. P.J.Redmond and J.L.Uretsky.
Ann. Phys. (New York), Vol. 9, No. 1, 106-24 (Jan., 1960).

It is pointed out that if one second-quantizes nonrelativistic quantum mechanics, it becomes amenable to treatments similar to those proposed for relativistic theories. Since nonrelativistic quantum mechanics is much better understood than the relativistic theories, it is possible to test any suggestions made for discussing the latter problem by applying them to the simpler model. In the course of such an investigation it is found that a method proposed by Zimmerman (Abstr. 2038 of 1959) for finding the commutation relations for the in and out operators contains an error. The investigation also suggests that none of the methods so far proposed for introducing in–out operators for bound states seem entirely satisfactory. It is suggested that the procedure used for the nonrelativistic problem has a natural generalization to the relativistic case, and this is outlined.

530.14

3453 THE LAGRANGIAN AND THE ENERGY–MOMENTUM TENSORS IN THE PERTURBATION THEORY OF CLASSICAL ELECTRODYNAMICS. E.L.Chu.
Ann. Phys. (New York), Vol. 9, No. 1, 76-92 (Jan., 1960).

The theory of infinitesimal transformations is incorporated in the variational principle for the solution of perturbation problems in classical electrodynamics. Every variable quantity is transformed to the unperturbed coordinate system and expanded into a power series of a small perturbation parameter. The Lagrangian of any given order of magnitude in the unperturbed coordinate system characterizes a closed physical system. This is proved by showing that the total energy–momentum tensors of the first and second orders are symmetric. The proof for the higher orders is obtained by deduction. Sturrock's asymmetric tensor (Abstr. 1507 of 1959) is recognized as being the result of using an incomplete Lagrangian. Small-amplitude solutions can also be obtained by first applying variation to the total Lagrangian function and then transforming and expanding the results in different orders of magnitude. This method, as exemplified by the proof of the symmetry of the second-order energy–momentum tensor, is in many cases more convenient.

530.14

3454 ON A METHOD OF DETERMINATION OF ELECTRONIC EIGENVALUES BY LINE INTEGRATION. J.Guy.
C.R. Acad. Sci. (Paris), Vol. 249, No. 11, 991-3 (Sept. 14, 1959). In French.

By transforming to a set of orthogonal coordinates in a system of one electron, or two paired electrons, such that surfaces of constant $\Psi$ (electronic wave-function) form one of the sets of coordinate surfaces, the corresponding eigenvalue can be written in terms of line integrals, along trajectories orthogonal to the $\Psi$-surfaces, in an infinite number of ways, some of which are suggested directly by symmetry. This could be used for testing the accuracy of a wave-function, or in a variational calculation. J.Hawgood

530.14

3455 ASYMPTOTIC SOLUTION OF EIGENVALUE PROBLEMS. J.B.Keller and S.I.Rubinow.
Ann. Phys. (New York), Vol. 9, No. 1, 24-75 (Jan., 1960).

A method is presented for the construction of asymptotic formulae for the large eigenvalues and the corresponding eigenfunctions of boundary value problems for partial differential equations. It is an adaptation to bounded domains of the method previously devised to deduce the corrected Bohr–Sommerfeld quantum conditions. When applied to the reduced wave-equation in various domains for which the exact solutions are known, it yields precisely the asymptotic forms of those solutions. In addition it has been applied to an arbitrary convex plane domain for which the exact solutions are not known. Two types of solution have been found, called the "whispering gallery" and "bouncing ball" modes. Applications have also been made to the Schrödinger equation.

## STATISTICAL MECHANICS
## TRANSFER PROCESSES

530.16 : 539.19

3456 DERIVATION OF HYDRODYNAMIC EQUATIONS FOR THE QUANTUM SYSTEMS OF DIATOMIC MOLECULES. R.Zelazny.
Phys. Rev., Vol. 117, No. 1, 1-11 (Jan. 1, 1960).

Bogolyubov's method of derivation of the hydrodynamic equations from a quantum-statistical formalism, based on the array of distribution operators for clusters of s molecules, is adapted to the derivation of the hydrodynamic equations for a fluid composed of diatomic molecules. The general form of the hydrodynamic equations with an additional equation of angular momentum, which is coupled with the momentum equation through the antisymmetric part of the stress tensor, is obtained and all the interesting hydrodynamic quantities are calculated. A general procedure of derivation of the hydrodynamic equations by successive approximations is proposed and the equations of zeroth approximation are discussed.

530.16

3457 MANY-BODY PROBLEM IN QUANTUM STATISTICAL MECHANICS. III. ZERO-TEMPERATURE LIMIT FOR DILUTE HARD SPHERES. T.D.Lee and C.N.Yang.

Phys. Rev., Vol. 117, No. 1, 12-21 (Jan. 1, 1960).

For Pt II, see Abstr. 897 of 1960. Using the method developed in Pt I (Abstr. 5385 of 1959), the thermodynamical properties at T = 0 of a dilute system of hard spheres are computed for small values of $\rho a^3$, where a is the diameter of the spheres and $\rho$ is the particle density.

530.16

### 3458 MANY-PROBLEM IN QUANTUM STATISTICAL MECHANICS. IV. FORMULATION IN TERMS OF AVERAGE OCCUPATION NUMBER IN MOMENTUM SPACE.

T.D.Lee and C.N.Yang.

Phys. Rev., Vol. 117, No. 1, 22-36 (Jan. 1, 1960).

Starting from Rules A and B of Pt I (Abstr. 5385 of 1959), is it shown that the grand partition function can be evaluated in terms of the statistical averages of the occupation number in momentum space. The final formulation is in terms of a simple variational principle. The procedure represents a concise and complete separation of the effect of the Bose—Einstein or Fermi—Dirac statistical character of the particles from the dynamical problem. In the case of Bose statistics, this formulation makes possible a systematic computation of all thermodynamic functions near the Bose—Einstein transition point in the gaseous phase. Applications to a system of hard spheres are discussed.

530.16

### 3459 BEHAVIOUR OF A SMALL QUANTIZED SYSTEM IN A WEAKLY DISSIPATIVE MEDIUM: SOME APPLICATIONS TO COULOMB INTERACTIONS.

F.Englert.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 78-91 (Sept., 1959). In French.

A Hamiltonian formalism is developed. The effect of the medium appears in this Hamiltonian through "renormalized" operators which are obtained from the primitive ones with the help of a temperature-dependent dynamical admittance tensor, differing from Kubo's admittance (Abstr. 8437 of 1957) by the replacement of a commutator by a product. This tensor, which exhibits causality, symmetry and thermodynamical relations, is shown, when the systems consist of particles interacting through a binary potential, to be essentially the one-sided Fourier transform of Van Hove's correlation function (Abstr. 5702 of 1958); using this result, it is possible to generalize the Pines—Nozieres (Abstr. 2026 of 1958) minority-carriers technique. The general theory is applied to Coulomb interactions, and some new results concerning charged particles moving in an electron gas and excitons in solids are derived.

530.16

### 3460 GROUND-STATE ENERGY OF BOSE—EINSTEIN GAS WITH REPULSIVE INTERACTION.

K.Sawada.

Phys. Rev., Vol. 116, No. 6, 1344-58 (Dec. 15, 1959).

The explicit evaluation of the ground-state energy of a Bose gas interacting through a two-body repulsive potential is given as an expansion essentially in powers of the density of the particles and the scattering length. It is shown that the problem can be treated by using diagrammatical analysis up to any orders. The energy was investigated up to the fourth order in the ordinary sense of a perturbation expansion in terms of the scattering length, but including terms up to infinite order for special classes of diagrams. The energy obtained contains in general a $\Sigma_n C_n \rho^n \ln \rho$ ($n \geq 2$, half-integer and integer) dependence, and the coefficient $C_2$ is evaluated. A self-consistent treatment is given following this analysis and is shown to lead to the formulation of Beliaev.

530.16

### 3461 REMARK ON DILUTE BOSE SYSTEMS.

J.Peretti.

Phys. of Fluids, Vol. 3, No. 1, 68-71 (Jan.-Feb., 1960).

Some results are given on the connection existing between the Lee—Huang—Yang theory for the interacting Bose systems, and the Bogolyubov theory. (See Abstr. 6893 of 1957 and 2137 of 1947).

530.16 : 536.48

### 3462 THE THEORY OF PHASE TRANSITIONS IN A BOSE GAS.

E.N.Shvetsov.

Fiz. Metallov. i Metallovedenie, Vol. 7, No. 4, 481-90 (1959). In Russian.

Formulae are derived for the discontinuity in the thermal capacity of a boson gas at the $\lambda$-point. These are applied to the cases of an uncharged gas and a gas of charged bosons in a magnetic field.

A.F.Brown

530.16

### 3463 ON THE THEORY OF THE TEMPERATURE GREEN'S FUNCTIONS.

V.L.Bonch-Bruevich and Sh.M.Kogan.

Ann. Phys. (New York), Vol. 9, No. 1, 125-38 (Jan., 1960).

The general theory of quantum Green's functions is developed for thermodynamical systems. The appropriate spectral theorem is proved and the relation of Green's functions to the energy spectrum and thermodynamical properties of the system is established. As an example the energy and damping constant of the "dressed electrons" in a nondegenerate electron gas are calculated.

530.16

### 3464 SPECTRAL REPRESENTATIONS OF TEMPERATURE GREEN'S FUNCTIONS WITH SEVERAL TIME VARIABLES.

V.L.Bonch-Bruevich.

Dokl. Akad. Nauk SSSR, Vol. 129, No. 3, 529-32 (Nov. 21, 1959). In Russian.

An expression is derived for a Green's function depending on three time coordinates, which refers to a system in equilibrium at a finite temperature, in terms of its spectral function. The spectral function is given explicitly. The analytic properties of the Green's function are discussed by splitting it into advanced and retarded functions. A brief discussion is given of how to generalize the equations for Green's functions which depend on more than three time variables.

D.J.Thouless

530.16

### 3465 ANALOGY BETWEEN THE MECHANICAL AND THERMODYNAMICAL EQUATIONS OF MOTION AND THE ONSAGER RECIPROCITY RELATION.

I.Fen'esh.

Zh. eksper. teor. Fiz., Vol. 35, No. 4(10), 1039-41 (Oct., 1958). In Russian. English translation in : Soviet Physics—JETP (New York), Vol. 35(8), No. 4, 725-6 (April, 1959).

Criticizes the work of Popov and Karanikolov (Abstr. 8717-18 of 1955), in particular the assumption of $X = \dot{\alpha}$ as the relation between the thermodynamic "force" and state vectors, which is said to be a restrictive and unfounded condition. The author suggests that the correct relation is $X = -(LgL)^{-1}\dot{\alpha}$, where L is the "conductivity" matrix and g is the symmetrical matrix of the second differentials of entropy. Onsager's relation that L is symmetrical does not follow, unless L is a symmetrical function of g. A mechanical model of irreversible thermodynamics is suggested in the form of rotation of a solid body of mass $(LgL)^{-1}$ about a point, retarded by anisotropic friction with coefficient $L^{-1}$.

J.Hawgood

530.16

### 3466 ON THE MATHEMATICS OF EXCHANGE PROCESSES IN FIXED COLUMNS. III. THE SOLUTION FOR GENERAL ENTRY CONDITIONS, AND A METHOD OF OBTAINING ASYMPTOTIC EXPRESSIONS.

S.Goldstein and J.D.Murray.

Proc. Roy. Soc. A, Vol. 252, 334-47 (Sept. 29, 1959).

For Pt I and II see Abstr. 7228-9 (1953). The equations for an exchange process between a suitable solid and a flowing fluid in a fixed column — e.g. heat exchange, ion exchange, adsorption or adsorption exchange — are solved explicitly for general entry conditions. It is shown how asymptotic expressions may be found for large values of the ratio of the exchange coefficient to the rate of volume flux of the fluid for the various cases that arise. The equations considered are reduced to

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \quad \epsilon \frac{\partial v}{\partial y} = u - rv + (r-1)\, uv,$$

in $x \geq 0$, $y \geq 0$, with the boundary conditions $v(x, 0) = 0$ for $x \geq 0$, and $u(0, y) = f(y)$ for $0 \leq y \leq Y$, $u(0, y) = 1$ for $Y \geq Y$, where $f(0) = 0$, $f(Y) = 1$, and $f(y)$ is monotonic in $(0, Y)$. Asymptotic expressions of the solution are sought for small $\epsilon$.

530.16

### 3467 ON THE MATHEMATICS OF EXCHANGE PROCESSES IN FIXED COLUMNS. IV. LIMITING VALUES, AND CORRECTION TERMS, FOR THE KINETIC-THEORY SOLUTION WITH GENERAL ENTRY CONDITIONS.

S.Goldstein and J.D.Murray.

Proc. Roy. Soc. A, Vol. 252, 348-59 (Sept. 29, 1959).

The methods described in Pt III are used to find the limiting value of u (the ratio of the concentration of one ion in the fluid to the total concentration of both ions at entry) as $\epsilon \to 0$, $\epsilon$ being the ratio of the volume flux of the fluid to the exchange coefficient, and also to find closer approximations in some cases for small but non-zero $\epsilon$. The formation, growth, and change of position of the singularity in the limiting value are discussed.

530.16

### 3468 ON THE MATHEMATICS OF EXCHANGE PROCESSES IN FIXED COLUMNS. V. THE EQUILIBRIUM-THEORY AND PERTURBATION SOLUTIONS, AND THEIR CONNEXION WITH KINETIC-THEORY SOLUTIONS, FOR GENERAL ENTRY CONDITIONS.

S.Goldstein and J.D.Murray.

Proc. Roy. Soc. A, Vol. 252, 360-75 (Sept. 29, 1959).

The equilibrium-theory equations for an exchange process in a fixed column are reduced to

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \quad u - rv + (r-1)\,uv = 0.$$

For $r < 1$, the solution for general entry conditions must become discontinuous. These solutions are obtained, and close approximations to the kinetic-theory solutions are found near the discontinuities by a method of singular perturbations. These are still not sufficiently satisfactory. Satisfactory approximations are obtained by improving the solutions away from the discontinuity by a method of non-singular perturbations, followed by a more refined discussion of the singular perturbations near the discontinuity. The results obtained all agree with those obtained by completely different methods in Pt IV. (The methods here used are first steps towards the development and use of similar techniques in cases where analytical solutions of the more nearly complete equations, such as the kinetic-theory equations for ion exchange, cannot be found).

530.16

### 3469 KINETIC THEORY OF MODERATELY DENSE RIGID SPHERE FLUIDS. III. THE FORMULATION AND SOLUTION OF THE TRANSPORT EQUATION FOR BINARY MIXTURES.

R.A.Harris and S.A.Rice.

J. chem. Phys., Vol. 32, No. 2, 538-47 (Feb., 1960).

For previous work, see Abstr. 11864-5 (1959). The theory of the moderately dense rigid sphere fluid is extended to mixtures. The modified Boltzmann equation is derived from the Liouville equation using the technique of time smoothing. The solution of the Boltzmann equation is given in terms of bracket integrals and the entropy production formulated in terms of the perturbation to the distribution function. The bracket integrals are not explicitly evaluated in this paper but a first order result valid for a mixture of spheres of equal diameters gives for the leading term of the diffusion coefficient $D = D^0/g_0^{(2)}(\sigma)$ with $D^0$ the dilute gas diffusion coefficient, and $g_0^{(2)}(\sigma)$ the pair correlation function evaluated at contact. This leading term is in agreement with the corresponding leading terms for the thermal conductivity and shear viscosity of a one component hard sphere fluid, which also differ from the dilute gas coefficients by the factor $[g_0^{(2)}(\sigma)]^{-1}$. The results quoted in this abstract are the leading terms and do not include all contributions of order $\nu^{-1}$.

530.16

### 3470 EXCLUSION FACTORS IN TRANSPORT THEORY.

E.I.Blount.

Phys. Rev., Vol. 116, No. 6, 1365-8 (Dec. 15, 1959).

It has recently been shown (Abstr. 5866 of 1958) that the customary exclusion factors should be omitted from the Boltzmann equation. This raises some conceptional difficulties in relation to the Pauli principle. The resolution of these difficulties is discussed.

530.16 : 539.12

### 3471 ELEMENTARY SOLUTIONS OF THE TRANSPORT EQUATION AND THEIR APPLICATIONS.

K.M.Case.

Ann. Phys. (New York), Vol. 9, No. 1, 1-23 (Jan., 1960).

A new method of treating problems involving the transport equation is discussed. Starting from Van Kampen's observation (Abstr. 3042 of 1956) that it is sufficient that "solutions" be distributions, the elementary solutions of the homogeneous equation are considered. These are found to have completeness and, in some cases, orthogonality properties which lead to the solution of more interesting problems by a conventional eigenfunction expansion. While the method is illustrated here with the simplest examples of neutron diffusion, it seems to be generally applicable.

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## GENERAL MECHANICS

531.2

### 3472 ON THE THEORY OF SHELLS OF MEDIUM THICKNESS.

Kh.M.Mushtari and I.G.Teregulov.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 6, 1144-7 (Oct. 21, 1959). In Russian.

The authors show that the principle of possible displacements can be used to derive the equilibrium equation of stressed shells of medium thickness, which can then be approximated with controlled accuracy. In particular, the equilibrium equation is derived, accurate within $(h/a)^4$, where h is the thickness and a the characteristic dimension of the shell. J.K.Skwirzynski

531.25

### 3473 SOME INTERRELATIONS BETWEEN SOLUTIONS OF PLANE AND OF AXIALLY-SYMMETRICAL PROBLEMS CONCERNING INFINITE PLATES.

A.Ya.Aleksandrov.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 1, 57-60 (Sept. 1, 1959). In Russian.

The author presents a method of transformation of a known solution, applicable to a rectangular plane distribution of stresses (dependent on one coordinate only), leading to a solution for a symmetrically polar distribution of stresses, for an infinite flat plate. The polar shear components are derived as solutions of an Abel's integral equation whose kernel is a potential function expressible in terms of known rectangular stress components.
J.K.Skwirzynski

531.25

### 3474 NEW SOLUTIONS FOR FINITE DEFORMATION.

B.R.Seth.

Proc. Indian Acad. Sci. A, Vol. 65, No. 2, 105-12 (Feb., 1957).

The use of finite components of strain shows that a plate can be bent into a spherical shell if suitable tractions are applied to the inner and outer surfaces and to the plane rim. The corresponding components of displacement have been obtained.

531.3

### 3475 THE CASE OF THE COUNTING BALLS.

J.V.Kline.

Amer. J. Phys., Vol. 28, No. 2, 102-3 (Feb., 1960).

The demonstration experiment involving a linear array of elastic spheres is discussed. In the simple case, where masses are equal, the number of emerging balls is equal to the number of incident balls, and in the more complicated case of unequal masses the balls do not know how to count.

531.3

### 3476 TRAJECTORIES INDEPENDENT OF MASS.

J.Katz.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 45, No. 4, 402-11 (1959). In French.

An investigation of the restrictions imposed upon the field of force and upon initial conditions if a stream of particles of differing masses is not separated in traversing the field. R.A.Newing

531.4 : 539.62

### 3477 ROLLING FRICTION OF A HARD CYLINDER OVER A VISCOELASTIC MATERIAL.

W.D.May, E.L.Morris and D.Atack.

J. appl. Phys. Vol. 30, No. 11, 1713-24 (Nov., 1959).

The rolling friction of a hard cylinder over a viscoelastic material is worked out in terms of the bulk properties of the material. It is found that the rolling friction has a maximum at a velocity corresponding to the peak of the relaxation time distribution. Both the load required to maintain the cylinder at constant depth of indentation and the coefficient of friction are dependent on the velocity of rolling. The shape of the rolling friction versus velocity curve is a first approximation to the distribution curve of relaxation times, indicating that rolling friction measurements can be used to determine the distribution experimentally.

531.4 : 539.62

### 3478 THEORY OF ROLLING FRICTION FOR SPHERES.

D.G.Flom and A.M.Bueche.

J. appl. Phys., Vol. 30, No. 11, 1725-30 (Nov., 1959).

A theory of rolling friction featuring the importance of elastic hysteresis losses is presented. A simple model of retarded elasticity is chosen to represent the physical properties of the material.

A prediction resulting from the theory is that the coefficient of friction for a relatively hard sphere rolling on a softer base material should vary with speed so as to go through a maximum. This relationship resembles closely the variation of mechanical loss with frequency. The results are not restricted to rolling but also apply to well-lubricated sliding where shearing forces have been minimized. Although the theory is developed for a material with idealized physical properties, it nevertheless affords a basis for comparing real materials and for predicting their frictional properties in cases where deformation losses are predominant.

531.5

3479 FOCUSING TRAJECTORIES FOR PROJECTILES IN AN INVERSE SQUARE FIELD. D.F.Dempsey.
Amer. J. Phys., Vol. 27, No. 9, 667-8 (Dec., 1959).

Previous work of Blitzer and Wheeldon is extended by a geometrical method which gives the location of the non-attracting focus of the elliptic orbit. E.G.Knowles

## MECHANICAL MEASUREMENTS

531.71

3480 HIGH-TEMPERATURE ROTOR BORE DILATOMETER UNIT. J.West.
J. sci. Instrum., Vol. 36, No. 1, 1-3 (Jan., 1959).

The instrument measures optically the dilation due to centrifugal stresses of the bore of a steam turbine rotor under running conditions. The measurements are independent of vibration of the rotor. Light from an illuminated pinhole within an autocollimator is collimated on to a system of three mirrors supported kinematically inside a cylindrical cartridge, which is pushed into the rotor bore of the turbine. Two of the mirrors are fixed to the cartridge, and the third is hinged and connected to a feeler which is spring loaded against the rotor bore. With all three mirrors mutually at right angles, the light is reflected back to the autocollimator in exactly its own path, independent of any relative movement between the dilatometer and the autocollimator. On expansion of the rotor bore, the third mirror is displaced, tilting the returned beam of light. Since the turbine rotor is rotating, the image seen in the autocollimator appears as a circle, the diameter of which gives a measure of the dilation. The preparation of the mirror surfaces enabling them to withstand the conditions inside the turbine is discussed.

531.71

3481 CRYSTAL FILM THICKNESS MONITOR. P.Oberg and J.Lingensjo.
Rev. sci. Instrum., Vol. 30, No. 11, 1053 (Nov., 1959).

Briefly describes the use as monitor of a resonating piezoelectric crystal in the deposition chamber during film deposition. E.G.Knowles

531.71 : 621.317.73

3482 INDUCTANCE BRIDGE FOR SENSITIVE DISPLACEMENT MEASUREMENTS OVER LONG PERIODS. D.Murray.
J. sci. Instrum., Vol. 36, No. 7, 312-15 (July, 1959).

An application of linear differential transformers in an a.c. bridge that provides reproducible displacement measurements over long periods, extends the linear response whilst retaining high sensitivity, and can be readily adapted for automatic recording of displacement.

531.72

3483 SEMI-EMPIRICAL METHOD OF DETERMINATION OF THE THICKNESS ALONG A THIN WEDGE-SHAPED LAYER. M.P.Lisitsa and V.M.Maevskii.
Pribory i Tekh. Eksper., 1959, No. 3, 113-18 (May-June). In Russian.

Formulae for the determination of thicknesses along thin wedge-shaped coatings on hard bases are obtained. Hence thicknesses along thin selenium layers are calculated and found to agree with those measured by means of an interference method. J.M.Zarzycki

531.75

3484 QUICK-ACTING CHEMICAL BALANCE. B.O.Smith and J.W.Stevens.
J. sci. Instrum., Vol. 36, No. 5, 206-9 (May, 1959).

For use in an analytical laboratory in which repetitive weighings are made to an accuracy of one part in 5000. The beam is balanced by an electronic servo system with a fast response speed and excellent long-term reliability.

531.75

3485 WEIGHT-IN-AIR BASIS OF ADJUSTMENT OF PRECISION WEIGHTS. P.H.Bigg.
J.sci.Instrum., Vol. 36, No. 8, 359-61 (Aug., 1959).

An explanation is given of the advantages and the limitations of the arrangement whereby analytical and similar weights of accuracy approaching one part per million (for example, 0.1 mg on 100 g) are adjusted and tested on the basis of weighings in air without applying buoyancy corrections. The paper has been occasioned by a decision taken recently by a number of national standards laboratories, including the National Physical Laboratory, to base their weight-in-air test, as from 1 July, 1959, exclusively on the densities 8.0 g/ml for the weights and 0.0012 g/ml for the air

531.75 : 621-526

3486 A PHOTOELECTRIC FOLLOWUP AND RECORDING SYSTEM, AND ITS APPLICATION TO REMOTE OBSERVATIONS OF THE BEAM IN HIGH-PRECISION BALANCES. H.A.Bowman and L.B.Macurdy.
J. Res. Nat. Bur. Stand., Vol. 63C, No. 2, 91-6 (Oct.-Dec., 1959).

A device is described which permits a significant increase in the frequency of the oscillations of the beam of a balance, thereby shortening the interval during which upsetting ambient conditions can act. The device is a servo-driven photoelectric follow-up system responding to the position-modulated light signal from a mirror attached to the balance 12 ft away from the photocell. Reproducibility in observing the position of the light beam is 0.001 in. or less.

531.76

3487 DIGITRON—A DIGITAL TIME ANALYZER FOR MICROSECOND INTERVALS. R.A.Swanson.
Rev sci. Instrum., Vol. 31, No. 2, 149-54 (Feb., 1960).

The data obtained by counting pulses from a 10-Mc/s ringing circuit are accumulated in a magnetic core memory. The measured standard deviation of channel widths is ≤0.15% and the drift in absolute time calibration is <0.1% for periods of several days.

531.76 : 621.317.39

3488 PHOTOELECTRIC APPARATUS FOR MEASURING VELOCITY. A.C.Gray and S.Thomas.
J. sci. Instrum., Vol. 36, No. 7, 305-6 (July, 1959).

The apparatus caters for projectiles 1-5 cm in diameter with velocities of 700-3500 cm/sec. The accuracy of measurement is approximately ±0.2%.

531.78 : 621.317.39

3489 TRANSMISSION DYNAMOMETERS. E.P.Kingsbury.
Rev. sci. Instrum., Vol. 130, No. 11, 1068 (Nov., 1959).

Proposes the use of two sine generators mounted a distance apart on the shaft so that when the shaft is carrying no torque the outputs are 180° out of the phase. The generators are connected in series and the voltage developed is directly proportional to the power transmitted. E.G.Knowles

## MECHANICS OF FLUIDS

*(See also Magnetohydrodynamics)*

532.1

3490 A GLAND FOR THE ROD OF A HIGH-PRESSURE [HYDRAULIC] INTENSIFIER. V.A.Borzunov and D.S.Mirinskii.
Pribory i Tekh. Eksper., 1959, No. 3, 152-3 (May-June). In Russian.

The intensifier and gland are described and detailed drawings given. The materials of construction and the details of design required to ensure satisfactory working and long life are specified. R.F.S.Hearmon

532.1

3491 MEASUREMENT OF THE FALLING VELOCITY OF PARTICLES IN OPAQUE FLUIDS.

V.Fidleris and R.L.Whitmore.
J. sci. Instrum., Vol. 36, No. 1, 35-6 (Jan., 1959).

An electromagnetic method of detecting the particles is employed.

532.1

3492

### FREE VOLUME APPROACH TO POLYISOBUTYLENE MELT VISCOSITY UNDER PRESSURE. H.Singh.

Ann. Phys. (Leipzig), Folge 7, Vol. 5, No. 5-6, 268-72 (1960).

The Doolittle (Abstr. 2836 of 1958) melt viscosity expression

$$\eta = A \exp(B/f)$$

has been applied to published data on polyisobutylene to calculate a parameter $a_P$ which is defined as the ratio of relaxation times at any pressure $P$ to those at a reference pressure. To check the results, the parameter $a_P$ has also been calculated by the method of reduced variables. The agreement between the theoretical and experimental values of $a_P$ is found to be very good. Also the treatment separates melt viscosity of polyisobutylene into two factors, A, dependent only on structural parameters, and f, which is determined by the specific volume and is a function of temperature and pressure.

532.2

3493

### ON THE STABILITY OF DISPLACEMENT FRONTS IN POROUS MEDIA: A DISCUSSION OF THE MUSKAT-ARONOFSKY MODEL. A.E.Scheidegger.

Canad. J. Phys., Vol. 38, No. 2, 153-62 (Feb., 1960).

It is well known that, during the displacement of a fluid contained in a porous medium by another less viscous one, the displacement front may become unstable: Fingers occur which proceed rapidly through the system. The Muskat-Aronofsky model of displacement in porous media, in which it is assumed that a sharp front exists with maximum saturation by the respective fluid being present on either side of the front, is analysed in the light of the phenomenon of fingering. It is shown that the Muskat-Aronofsky model, in fact, demands that fingering occurs for mobility ratios (displaced/displacing fluid) smaller than one. This model should, therefore, not be used for the calculation of the steady progress of a front for such mobility ratios. The Muskat-Aronofsky model also yields some conditions regarding the geometry of fingers; the latter are deduced. It does not, however, describe the fingering process completely. In this connection, one would have to take recourse to the statistical geometry of porous media. This will be done in a separate paper.

532.5

3494

### CHRISTIANSEN-TYPE TRANSPARENT POROUS MEDIA FOR FLOW STUDIES. J.P.Heller.

Rev. sci. Instrum., Vol. 30, No. 11, 1056-7 (Nov., 1959).

Granulated crystalline $CaF_2$ has been used successfully as a porous pack forming a Christiansen filter. If the pack is illuminated from behind with collimated light of appropriate wave-length and observed through an aperture, it can be arranged that tracer-free liquid flowing through the pack is transparent while liquid containing a trace of soluble dye is opaque. J.G.Oldroyd

532.5

3495

### GROWTH OF INSTABILITIES ON DISPLACEMENT FRONTS IN POROUS MEDIA. A.E.Scheidegger.

Phys. of Fluids, Vol. 3, No. 1, 94-104 (Jan.-Feb., 1960).

The problem investigated is that of the penetration of a fluid into a porous medium containing a more viscous liquid. In order to do this, the flow potentials for a displacement front which is just about to become unstable are calculated. For such a displacement front it is possible to linearize the differential equations, and to give a description in terms of Fourier analysis. The law of growth for each spectral component of the front is deduced, and it is shown how the time dependence of the whole front can be represented by a superposition of elemental solutions. Subsequently, the effect of the heterogeneities contained in the porous medium is accounted for by introducing a random velocity perturbation term into the differential equation for each spectral component. In this fashion one arrives at an equation describing the growth of each spectral component of the fingers with time. It is shown that, under given external conditions, fingering should be independent of the speed with which the displacement proceeds. This is, in fact, what has been observed experimentally.

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3496

### HELICAL FLUID FLOWS. R.H.Wasserman.

Quart. appl. Math., Vol. 17, No. 4, 443-5 (Jan., 1960).

532.5

3497

### NORMAL STRESS EFFECT IN POLYMER SOLUTIONS. T.Kotaka, M.Kurata and M.Tamura.

J. appl. Phys., Vol. 30, No. 11, 1705-12 (Nov., 1959).

Normal stress phenomena are studied in solutions of some typical high polymers, polystyrene, methylcellulose and sodium-carboxymethylcellulose, with a parallel plate instrument. The principle of procedures for separate determination of normal stress components with the parallel plate instrument is briefly described. The normal stress measurements are performed in shearing rates ranging from about 1.0 to 100. The results obtained together with the flow curves, are discussed in terms of the cross-elasticity theory and of some molecular bases. It is concluded that polystyrene solutions roughly obey "Hooke's law in shear", while solutions of cellulose derivatives are remarkably "non-Hookean in shear".

532.5

3498

### BOUNDARY LAYER OVER A FLAT PLATE IN PRESENCE OF SHEAR FLOW. Lu Ting.

Phys. of Fluids, Vol. 3, No. 1, 78-81 (Jan.-Feb., 1960).

The governing equations of an incompressible boundary layer over a flat plate in the presence of a shear flow with finite vorticity are derived. For large vorticity, a similarity solution is obtained. For moderate vorticity, one of the governing equations is replaced by an approximate one for which similarity solutions exist.

532.5 : 539.5

COMPARISON OF FLOW LINES IN VARIOUS TYPES OF RHEOLOGICAL BODIES. See Abstr. 3161

532.5

3499

### A DERIVATION OF THE BASIC EQUATIONS FOR HYDRODYNAMIC LUBRICATION WITH A FLUID HAVING CONSTANT PROPERTIES. H.G.Elrod.

Quart. appl. Math., Vol. 17, No. 4, 349-60 (Jan., 1960).

Small parameter techniques are used to derive Reynolds lubrication equations, and refinements thereof, from the full Navier–Stokes equation. An effort has been made to retain rigor in the development comparable to that used in present-day boundary-layer developments.

532.5

3500

### COOLING-WATER-FLOW ALARM. L.Patý.

Pribory i Tekh. Eksper., 1959, No. 3, 155 (May-June). In Russian.

Describes a very simple alarm device for use with cooling water for flow rates between 15 and 180 litres per hour.
J.M.Zarzycki

532.5

3501

### ONE-DIMENSIONAL EQUILIBRIUM SPECTRA IN ISOTROPIC TURBULENCE. W.H.Reid.

Phys. of Fluids, Vol. 3, No. 1, 72-7 (Jan.-Feb., 1960).

The one-dimensional equilibrium spectra in isotropic turbulence are given for the physical transfer theories of Heisenberg, Kovasznay and Obukhoff (Abstr. 469 of 1949; Journal of Aeronautical Science, Vol. 15, p. 745, 1948; and Comptes Rendus de l'Academie des Sciences de l'U.R.S.S, Vol. 32, p. 19, 1941). These results are then compared with the experimental measurements of the spectrum of $\partial^3 u_1/\partial x_1^3$ fluctuations. For two of the theories (Heisenberg's and Kovasznay's), reasonable agreement is obtained for $k\eta < 0.04$, but for larger values of $k\eta$ there is considerable divergence between the theoretical and experimental results. The relationship between the equilibrium and similarity spectra are also discussed for these two theories.

532.5 : 534.23

HYDRAULIC OSCILLATOR FOR THE DYNAMIC CALIBRATION OF PRESSURE RECORDING SYSTEMS. See Abstr. 3587

532.5 : 534.13

3502

### THEORY OF OSCILLATION OF A VISCOELASTIC MEDIUM BETWEEN PARALLEL PLANES. G.B.Thurston.

J. appl. Phys., Vol.30, No.12, 1855-60 (Dec., 1959).

A theoretical description of sinusoidal oscillation of an incompressible viscoelastic medium between fixed infinite parallel planes is presented. The mechanical properties of the viscoelastic medium under sinusoidal shear are expressed by a complex viscosity coefficient. The general equation for oscillatory motion of an incompressible viscoelastic medium is developed. The solution to this equation is obtained for rectilinear motion parallel to a pair of infinite planes. The equation for the velocity distribution between the planes is developed and several typical profiles are presented graphically. The equation for the acoustic impedance per unit area of plane is obtained. Functions from which the acoustic resistance and acoustic reactance may be determined are presented in graphical form for media which range from a perfect viscous fluid to a perfect elastic solid. The applicability of the theoretical results to oscillatory flow in rectangular tubes is discussed.

532.6

3503 MEASUREMENT OF DYNAMIC SURFACE TENSIONS OF AQUEOUS SOLUTIONS BY THE FALLING MENISCUS METHOD. R.Defay and J.R.Hommelen.
J. Colloid Sci., Vol. 14, No. 4, 401-10 (Aug., 1959).

In Pt I, see Abstr. 2132 of 1959. Experiments have been made to explore the influence on dynamic surface tension of evaporation of solute, extension of surface area, and pollution of the surface by contact with an aged surface. R.Schnurmann

532.6

3504 INTERPRETATION OF THE RELAXATION OF SURFACE TENSION. W.Göring.
Z. Elektrochem., Vol. 63, No. 9-10, 1077-80 (1959). In German.

Maxwell's formulation of the relaxation of elastic stress is modified in such a way that it applies to the relaxation of surface tension, resulting in an expression for the surface viscosity. The author assumes that the experimental relaxation of surface tension is due to a process of re-arrangement of molecules in the surface involving the exchange between different molecules of occupied sites. R.Eisenschitz

532.6

3505 INTERFACIAL TENSION SOLID—LIQUID OF BENZENE. A.Skapski, R.Billups and D.Casavant.
J. chem. Phys., Vol. 31, No. 5, 1431 (Nov., 1959).

A value of 21.7 ± 2 ergs/cm$^2$ is deduced for this interfacial tension, using benzene of very high purity. Difficulty was experienced in obtaining large enough single crystals in benzene not entirely free from moisture, and the importance of using crystals having no strains is stressed. G.I.W.Llewelyn

## LIQUID STATE

*(Liquid helium is included under Low-Temperature Physics)*

532.7

3506 QUANTUM MECHANICAL CELL MODEL OF THE LIQUID STATE. I. J.M.H.Levelt and R.P.Hurst.
J. chem. Phys., Vol. 32, No. 1, 96-104 (Jan., 1960).

The cell model for the liquid state, as proposed by Lennard-Jones and Devonshire, is recast in terms of quantum statistical mechanics. A method is developed by which the energy levels and wave-functions in the liquid cell can be determined to any prescribed accuracy. Thus, no additional approximations are introduced which are not inherent in the cell model. When a sufficient number of energy levels is obtained, the partition function and thus the thermodynamic properties are derived. A method is devised by which from a knowledge of the wave-function, the derivative of the corresponding energy with respect to the volume may be obtained. This derivative is required for the evaluation of the pressure. The theory is applied to $H_2$ and $D_2$ at a density near that of the crystals at 0°K. The corresponding classical Lennard--Jones and Devonshire thermodynamic functions are obtained and compared with the results of the present theory. The calculations involved were performed on a Bendix G-15D computer. The quantized cell theory predicts that for hydrogen and deuterium experimentally detectable differencies in energy, entropy, and specific heat must persist at temperatures as high as −150°C.

532.7

3507 ASPECTS OF THE STATISTICAL THERMODYNAMICS OF REAL FLUIDS. H.Reiss, H.L.Frisch, E.Helfand and J.L.Lebowitz.
J. chem. Phys., Vol. 32, No. 1, 119-24 (Jan., 1960).

By extending the ideas previously applied to the statistical mechanical theory of hard sphere fluids (Abstr. 10624 of 1959), an approximate expression has been determined for the work of creating a spherical cavity in a real fluid. In turn the knowledge of this entity permits an evaluation of properties such as the surface tension and the normal heats of vaporization of fluids and the Henry's law constants of fluid mixtures. The agreement between the calculated and experimental properties is satisfactory.

532.7

3508 "IMPROVED" FREE-VOLUME THEORY OF LIQUIDS. II. J.S.Dahler and J.O.Hirschfelder.
J. chem. Phys., Vol. 32, No. 2, 330-49 (Feb., 1960).

For Pt I, see Abstr.8024 (1956). The Kirkwood nonlinear integral equation for determining the optimum free volume of a liquid is integrated by an iterative procedure with the approximation that the cell distribution function is spherically symmetrical. The potential of the system is assumed to be pairwise additive and the interaction between two molecules obeys the Lennard-Jones 12-6 potential. To simplify the computations, the contributions to the cell potential by molecules beyond the first shell of nearest neighbours are calculated as though the molecules were located at their lattice points. The method of Levine, Mayer, and Aroeste was used to optimize the lattice dimensions and take into account the existence of holes. Extensive tables are given for the configurational internal energy, compressibility factor, and configurational entropy. Comparison of the configurational internal energy and compressibility factor with the Monte Carlo calculations indicates that the isotherms correspond to extensions of the crystalline phase into a metastable low density region. Comparison of the configurational entropy with experimental data indicates a lack of the entropy of fusion. The values of the configurational internal energy agree rather well and the values of the compressibility factor agree very poorly with the experimental data. Comparisons are also made with the results of other theoretical treatments.

532.7

3509 LIOUVILLE'S EQUATION FOR A WEAKLY INTERACTING GAS POSSESSING INTERNAL DEGREES OF FREEDOM. O. Von Roos.
J. chem. Phys., Vol. 31, No. 5, 1415-16 (Nov., 1959).

An arbitrary fluid of particles with internal degrees of freedom is studied quantum-mechanically. The quantum analogue of Liouville's theorem is an integro-differential equation for the Wigner phase-space distribution function. The way in which this equation can be transformed in the absence of chemical forces, using symmetry considerations, is outlined. O.Penrose

532.7

3510 ASYMPTOTIC VALUE OF THE PAIR DISTRIBUTION NEAR A WALL. J.L.Lebowitz.
Phys. of Fluids, Vol. 3, No. 1, 64-8 (Jan.-Feb., 1960).

The asymptotic value of the pair probability density $\rho_2(r_2,r_1)$ is calculated for finding a fluid particle at a point $r_2$ far in the interior of a fluid, when it is known that there is a particle at $r_1$ in contact with the walls (rigid) of the container. This value is different from the well-known expression for the asymptotic value of $\rho_2(r_2,r_1)$ when both $r_2$ and $r_1$ are in the interior of the fluid. The derivation is based on the virial theorem for total momentum fluctuations in an equilibrium system and makes use of the assumption that there are no long range correlations in a fluid. Application is made of the result to rederive simply the expression for the second virial coefficient and the exact equation of state of a hard-sphere gas in one dimension. Quantum systems are also treated.

532.7

3511 MUTUAL EFFECT OF DIFFUSION FLOWS IN MULTICOMPONENT SYSTEMS. P.Ya.Siver.
Dokl. Akad. Nauk SSSR, Vol. 127, No. 5, 1062-5 (Aug. 11, 1959). In Russian.

The simultaneous diffusion of the labelled ($HP^{32}O^{--}$) and unlabelled ($HP^{31}O^{--}$) diphosphate ion in the system water/disodium phosphate/non-electrolyte (urea, glucose, lactose, glycerol) was investigated. It was found that there exists an almost linear relation between the coefficient of diffusion of the labelled ion and the concentration gradient of the unlabelled one, and, consequently, the diffusion flow of the labelled ion depends linearly on the diffusion flow of the unlabelled one. F.Lachman

532.7

### 3512 METHOD FOR THE DETERMINATION OF DIFFUSION COEFFICIENTS IN LIQUIDS. II.

F.Grün and B.Marzetta.
Helv. phys. Acta, Vol. 32, No. 4, 339-48 (1959). In German.

For Pt I, see Helvetica Chimica Acta, Vol. 41, 2156 (1958). It is shown that the value of the diffusion coefficient in liquids is rather insensitive to variations in experimental conditions when there is an asymptotic approach to a straight-line relationship. The case has been considered in which a thin layer of a material containing radioactive tracers has been covered by a column of liquid in which it dissolves and diffuses. R.Schnurmann

532.7

### 3513 DIFFUSION IN LIQUIDS.

D.W.McCall, D.C.Douglass and E.W.Anderson.
J. chem. Phys., Vol. 31, No. 6, 1555-7 (Dec., 1959).

Self-diffusion coefficients were measured for water, nitromethane, acetone, benzene, cyclohexane, isopentane, and neopentane. Temperature and pressure dependences were determined for nitromethane, acetone, cyclohexane, and isopentane. The temperature dependence was determined for neopentane and the pressure dependence was determined for water and benzene. The results are discussed in terms of a semiempirical theory for transport in liquids and it is shown that semiquantitative predictions of self-diffusion, viscosity, and thermal conductivity coefficients can be made.

532.7

### 3514 SELF-DIFFUSION IN LIQUID ARGON.

G.Cini-Castagnoli and F.P.Ricci.
J. chem. Phys., Vol. 32, No. 1, 19-20 (Jan., 1960).

The self-diffusion coefficient of liquid argon was measured by the capillary technique at 84.56 ± 0.04°K and at about 70 mm Hg. The average value of $D(A^{37}-A^{40})$ is $(1.53 \pm 0.03)10^{-5}$ cm²/sec.

532.7

### 3515 DIFFUSION OF CERIUM AND ZIRCONIUM IN MOLTEN URANIUM. T.Smith.

J. Electrochem. Soc., Vol. 106, No. 12, 1046-51 (Dec., 1959).

Coefficients for the diffusion of cerium in molten uranium were measured over the temperature range 1170° - 1480°C. An equation relating the diffusion coefficient with temperature is: $D = 4.5 \times 10^{-3}e - 11\,000/RT$. At 1200°C the diffusion coefficient for cerium in uranium is $(1.00 \pm 0.17) \times 10^{-4}$ cm²/sec. An estimate of the coefficient of diffusion for zirconium in uranium at 1270°C is $(1.9 \pm 0.9) \times 10^{-4}$ cm²/sec. A discussion of experimental errors involved in measuring diffusion coefficients at high temperatures is given.

532.7

### 3516 ROLE OF THERMAL DIFFUSION IN THE ELECTROLYTIC SEPARATION OF ISOTOPES IN LIQUID METALS.

P.C.Mangelsdorf, Jr.
J. chem. Phys., Vol. 32, No. 1, 293-5 (Jan., 1960).

From the principles of irreversible thermodynamics and the known properties of metals it is inferred that there is a contribution to the Haeffner effect isotope separations arising from the isothermal heat flux accompanying the current flow. The magnitude of this contribution is estimated to be a significant fraction of the observed effect, but of opposite sign.

532.7 : 539.2 : 548.7 : 539.214

### 3517 ATOMIC DISTRIBUTIONS IN LIQUID, PLASTIC, AND CRYSTALLINE SULFUR.

C.W.Tompson and N.S.Gingrich.
J. chem. Phys., Vol. 31, No. 6, 1598-604 (Dec., 1959).

X-ray diffraction patterns were obtained, using improved technique, for liquid sulphur at 80°C (super-cooled), 120°, 165°, 200°, 240°, and 300°C; and for amorphous sulphur at 4°C and for powdered crystalline orthorhombic sulphur at 23°C, confirming reported new details at small angles and extending observations to nearly twice the range of $(\sin\theta)/\lambda$ heretofore reported. Atomic distribution curves are presented for all these cases. Nearest neighbour distances and numbers remain constant throughout at 2.07 A and 2 atoms, respectively, but other features of the distribution curves change with temperature. New results with neutron diffraction at 120°C are compared with these X-ray results.

532.7

### 3518 APPLICATION OF BRØNSTED'S PRINCIPLE OF CONGRUENCE TO N-ALKANE MIXTURES. J.Hijmans.

Molecular Phys., Vol. 1, No. 3, 307-10 (July, 1958).

Published results for volume contraction on mixing, and for enthalpy of mixing, are plotted to show the high mutual consistency between different mixtures from the standpoint of the principle of congruence. J.Hawgood

532.7

### 3519 CLUSTER FORMATION IN PERFLUOROHEPTANE—i-OCTANE SYSTEMS NEAR THE CONSOLUTE TEMPERATURE. G.W.Brady.

J. chem. Phys., Vol. 32, No. 1, 45-51 (Jan., 1960).

Small-angle X-ray measurements on the system $C_7F_{16}$—i-$C_8H_{18}$ at temperatures near the consolute temperature show that a large degree of clustering takes place. Starting with pure i-$C_8H_{18}$, which exhibits no scattering, the scattered intensity increases with increasing $C_7F_{16}$ concentration in a manner which indicates that the clusters are increasing in size. The maximum size is attained at a volume fraction of ~ 0.50, at which point the clusters are made up of ~ 140 $C_7F_{16}$ molecules. With a further increase in concentration, interaction peaks first appear in the intensity curves, indicating an approach to close packing, and then the slope of the curves begins to decrease, indicating that a phase reversal has taken place giving rise to smaller clusters of hydrocarbon in perfluorocarbon.

532.7

### 3520 INHOMOGENEOUS FIELD METHOD FOR THE STUDY OF LARGE POLARIZABLE PARTICLES.

A.Prock and G.McConkey.
J. chem. Phys., Vol. 32, No. 1, 224-36 (Jan., 1960).

An inhomogeneous electric field applied to a solution of polarizable particles causes a movement of the particles toward the region of lowest potential energy. The resulting creation of concentration gradient can be observed for large particles, by a method involving measurement of capacitance change of a cylinder containing a solution of the polymer. This effect has been measured in terms of weight average molecular weight; the system investigated is polystyrene in cyclohexane. The basic Debye theory relating capacitance change at equilibrium to weight average molecular weight has been extended to make it applicable to experimental conditions found to be necessary in work with random coil polymers. The theory is substantiated by the agreement obtained between molecular weight calulated by this method and by the method of light scattering. The polarizability of the particles present determines not only their equilibrium position, but also the rate at which they move. This idea is the basis of a theory presented here relating the time dependence of capacitance change to molecular weight distribution of a given sample. Another theory presented here shows how the shape of the curve for capacitance change as a function of applied field strength is related to the moments of the weight distribution function of the polarizable substance.

532.7

### 3521 DETERMINATION OF ATOMIC DISTRIBUTIONS IN LIQUID LEAD—BISMUTH ALLOYS BY NEUTRON AND X-RAY DIFFRACTION. P.C.Sharrah, J.I.Petz and R.F.Kruh.

J. chem. Phys., Vol. 32, No. 1, 241-6 (Jan., 1960).

The intensity of scattered neutrons and X-rays was measured for molten alloys and pure components in the system lead—bismuth. A specially designed diffraction spectrometer was constructed for the X-ray determinations. The diffraction data have been treated to give atom distributions, and the first main peak in the distribution curves for solutions up to about 60 wt % bismuth corresponds to 12 nearest neighbours, with the value falling to about 7.7 for pure bismuth. No unusual features were found in the eutectic region, but the density decrease on melting of lead-rich solids is puzzling in view of the retention of 12 nearest neighbours at a mean distance shorter than in the crystal. A model of average pentagonal dodecahedral coordination is suggested to account for this and for the spacing of first maxima in the distribution curves.

532.7

### 3522 ENERGY REQUIREMENTS OF MECHANICAL SHEAR DEGRADATION IN CONCENTRATED POLYMER SOLUTIONS. A.B.Bestul.

J. chem. Phys., Vol. 32, No. 2, 350-6 (Feb., 1960).

Molecular weight decrease by mechanical shearing results when solutions of around 10% of polyisobutene having average molecular weights above 500 000 are forced through a capillary at nominal rates of shear above 10 000 sec⁻¹. Comparison of observed plots of shear load versus duration of shearing at fixed rates of shear during this degradation process with the corresponding estimated plots which would be expected to obtain if degradation did not occur provide a means of evaluating the amount of applied shearing energy which is dissipated by the degradation process. The result is several hundred thousand kilocalories per mole of broken bonds, which is several thousand times the bond energy of carbon—carbon bonds. This finding is consistent with the hypothesis that whenever a bond breaks the system loses much of the free energy temporarily stored in bonds and macromolecular chains located in a comparatively large volume surrounding the broken bond, these bonds and chains having been involved in concentrating the required activation energy into the ruptured bond.

532.7

### 3523 TRANSMISSION MEASUREMENTS WITH COLD NEUTRONS IN HYDROGENOUS LIQUIDS.

R.Nasuhoglu and G.R.Ringo.
J. chem. Phys., Vol. 32, No. 2, 476-80 (Feb., 1960).

Measurements were made of the transmission cross-sections of several series of organic liquids for neutrons in the wavelength region of 5-20 A. These cross-sections should show effects from weak bonds, since the scattering cross-section of hydrogen is quite sensitive to the binding of hydrogen. Results of the measurements and a description of the helical velocity selector used in making them are given. The results give evidence that the hydrogens of the methyl group are relatively free in liquids.

532.7

### 3524 VELOCITY OF COMPRESSIONAL WAVES IN LIQUID HYDROGEN FLUORIDE AND SOME THERMODYNAMIC PROPERTIES DERIVED THEREFROM.

R.T.Lagemann and C.H.Knowles.
J. chem. Phys., Vol. 32, No. 2, 561-4 (Feb., 1960).

The velocity of compressional waves (sound waves) was measured in liquid hydrogen fluoride over the temperature range –15-19°. Using values of density and the specific heat at constant pressure from the literature, values of the following thermodynamic properties have been calculated over the same temperature range: adiabatic compressibility, isothermal compressibility, volume coefficient of expansion, specific heat at constant volume, and the ratio of specific heats.

532.7 : 534.23

### 3525 PROPAGATION OF ULTRASONIC WAVES IN LIQUIDS.

A.K.Dutta, M.Subudhi and K.Samal.
Nature (London), Vol. 184, 352-3 (Aug. 1, 1959).

Experimental evidence is presented which explains the anomalies in absorption measurements in xylene and benzene previously reported (Abstr. 3816 of 1958), and gives some information on the origin of flow energy. H.D.Parbrook

532.7 : 536.24

### 3526 THE HEAT-TRANSFER AND HIGH-TEMPERATURE PROPERTIES OF LIQUID ALKALI METALS.

I.I.Novikov, A.N.Soloviev, E.M.Khabakhnasheva, V.A.Gruzdev, A.I.Pridantzev and M.Ya.Vasenina.
J. nuclear Energy, Vol. 4, No. 3, 387-408 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4, 92 (1956).

The heat transport properties of liquid sodium in turbulent flow through circular copper and nickel tubing have been investigated and an empirical formula determined. The thermal resistances at the interfaces between liquid sodium and solid copper, nickel and stainless steel were also investigated. Methods of measurement of the viscosity, thermal diffusivity and the density of liquid metals are described. Data on these properties of the liquid alkali metals (sodium, potassium, lithium, Na-K eutectic alloy) are given throughout a wide temperature range.

532.7 : 537.2

### 3527 ELECTRICAL CONDUCTION IN LIQUID DIELECTRICS UNDER PULSE CONDITIONS.

K.A.Macfadyen and G.C.Helliwell.
J. Electrochem. Soc., Vol. 106, No. 12, 1022-7 (Dec., 1959).

The need for a method of measuring conduction in pure nonpolar dielectric liquids under pulse conditions is considered, and details of a measurement technique are given. Experiments with hexane show that currents greater than $10^{-5}$ amp flow with certain electrode conditions, at a field strength of about 200 kV/cm, although the d.c. conduction is much lower. A tentative explanation is offered.

532.7 : 537.2

### 3528 TEMPERATURE AND CONCENTRATION OF THE DIELECTRIC CONSTANT OF MIXTURES OF ORGANIC LIQUIDS AND WATER.

G.P.Srivastava and Y.P.Varshni.
Z. Phys. Chem. (Leipzig), Vol. 213, No. 1-2, 30-6 (1960).

A relation expressing the dependence of the dielectric constant on temperature (T) and concentration (c) of different types of mixture of organic liquids and water is suggested:

$$\epsilon = \left(l + \frac{m}{T}\right) + \left(p + \frac{q}{T^{1/2}}\right)c + \left(u + \frac{v}{T^{1/2}}\right)c^2,$$

where l, m, p, q, u, and v are constants. For some of the simpler mixtures v = 0, u = 0. The relation is shown to give satisfactory results for seven mixtures.

532.7 : 535.3

### 3529 OPTICAL PROPERTIES OF CONCENTRATED SOLUTIONS AND MELTS. I.

V.A.Kizel' and V.M.Rubinov.
Optika i Spektrosk., Vol. 7, No. 1, 62-70 (July, 1959). In Russian.

The refractive index n and the absorption coefficient $\chi$ of concentrated solutions of nitrosodimethylaniline, fuchsin, crystal violet, rhodamine 6 Zh, methylene blue and of bromine were found by the selective reflection method. The solvent used was aniline and measurements were made on solutions with a wide range of concentrations. Comparison of the experimental curves of the reflection coefficient plotted against frequency with those calculated using the classical dispersion theory and Davÿdov's quantum theory (Abstr. 7313 of 1954), showed clearly the superiority of the latter. A.Tybulewicz

532.7 : 535.33

### 3530 BROADENING OF THE SCATTERING LINE AND THE ORIENTATIONAL RELAXATION TIME OF SOLUTIONS.

A.K.Atakhodzhaev, M.F.Vuks and K.V.Plaksina.
Optika i Spektrosk., Vol. 4, No. 6, 763-6 (June, 1958). In Russian. English summary: PB 141047T-11, obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

Transition from the pure liquid to a solution is accompanied by broadening of the scattering line. This has been studied for a series of liquids of intense anisotropic scattering in solution in solvents of weak anisotropic scattering. The relaxation times for most of the solutions studied are considerably smaller than those of the pure liquids. G.I.W.Llewelyn

532.7 : 535.33

### 3531 SPECTRA OF SOME TRANSITION METAL IONS AND COMPLEXES IN $D_2O$.

J.Halpern and A.C.Harkness.
J. chem. Phys., Vol. 31, No. 4, 1147-9 (Oct., 1959).

Reports measurements of the spectral shifts, caused by substituting $D_2O$ for $H_2O$ as solvent, for the ions $X(H_2O)_6^{2+}$ (where X can be Ni, Co or Cu), $Fe(H_2O)_6^{3+}$, $Cr(H_2O)_6^{3+}$, $Cr(C_2O_4)_3^{3-}$ and $MnO_4^-$. The shifts appear to be due to isotopic substitution in the first coordination sphere rather than to longer-range effects. These isotope effects should be taken into account in studies of reaction mechanisms. J.Hawgood

532.7 : 535.33

### 3532 INTERACTION BETWEEN BENZENE AND N-MONO-SUBSTITUTED AMIDES.

I.Suzuki, M.Tsuboi, T.Shimanouchi and S.Mizushima.
J. chem. Phys., Vol. 31, No. 5, 1437-8 (Nov., 1959).

Infrared absorption measurement on N-methylacetamide, N-methylformamide, acetanilide, and caprolactam in solution in benzene and $CCl_4$ and in binary systems of these two solvents show that a complex is formed between the amide and benzene. G.I.W.Llewelyn

532.7 : 535.33

### 3533 VIBRATIONAL INTENSITIES OF BENZENE IN THE LIQUID PHASE.

I.C.Hisatsune and E.S.Jayadevappa.
J. chem. Phys., Vol. 32, No. 2, 565-72 (Feb., 1960).

The intensities of the four fundamental absorption bands in liquid benzene were measured by using the Wilson—Wells method. In addition, the intensity of the 15 $\mu$ CH bond out-of-plane bending mode absorption band was measured in cyclohexane, isooctane, methyl formate, and ethyl propionate solutions at five different concentrations. The solution values were in all cases larger than the pure liquid result. The effect of iodine in the most dilute solution of each solvent was also investigated, but no apparent difference from the simple solution was observed. The variations in the intensity, the band width, and the peak frequency with concentration found here suggest the existence of pronounced intermolecular interactions in liquid benzene.

532.7 : 535.33

### 3534 STUDIES OF THE TEMPERATURE DEPENDENCE OF THE INFRARED ABSORPTION BAND INTENSITIES IN LIQUIDS.

P.A.Bazhulin and V.N.Smirnov.

Optika i Spektrosk.,Vol. 6, No. 6, 745-53 (June, 1959). In Russian.

Deals with the temperature dependence of the intensities of vibrational bands (infrared absorption in the region 3-15$\mu$) in organic polar and non-polar liquids between -100 and +180°C. The majority of the observed bands fall in intensity with rise of temperature contradicting Plachek's prediction (1935). This behaviour is ascribed to intermolecular interactions in liquids, but no suggestions are offered about the nature of these interactions. A.Tybulewicz

532.7 : 535.33

### 3535 A STUDY OF EQUILIBRIA DURING FORMATION OF THE HYDROGEN BOND IN SOLUTIONS, USING INFRARED ABSORPTION SPECTRA. THE CASE OF INSEPARABLE BANDS.

M.O.Bulanin, G.S.Denisov and D.N.Shchepkin.

Optika i Spektrosk., Vol. 7, No. 2, 187-92 (Aug., 1959). In Russian.

Discusses theoretical determination of the equilibrium constant K of the reaction of hydrogen-bond formation, and the integral absorption coefficients $\epsilon_k$ of molecules which make up an associated complex, formed by means of a hydrogen bond between a solvent molecule and a solute molecule. The discussion deals with the case when the absorption bands of the monomer and the complex are overlapping. Equilibrium of the type $A + B \rightleftharpoons AB$ (where A is the solute and B is the solvent) is considered. It is shown that the treatment of the experimental results described by Lord et al. (Abstr. 4853 of 1955) leads to considerable errors. A better method of determination of K and $\epsilon_k$ is described: this method uses the least-squares technique. A.Tybulewicz

532.7 : 535.37

### 3536 THEORY OF FLUORESCENCE TIME CONSTANT MEASUREMENTS IN LIQUID AND RIGID SOLUTIONS.

H.Kallmann.

Phys. Rev., Vol. 117, No. 1, 36-8 (Jan. 1, 1960).

Formulae are derived for the dependence of fluorescence upon time for the case when energy transfer from the solvent to the solute is involved. Three cases are considered: excitation by single fast particles, excitation by one burst of particles during a given period, and periodic excitation. One important point is that in the rise and decay of fluorescence from a burst of particles, it is the difference of two exponential functions and not their sum which occurs. The results are compared with the experiments of Burton and Dreeskamp, of Swank and Buck, and of Knau. These experiments are in general accordance with the derived formulae.

532.7 : 535.37

### 3537 ON THE METASTABLE STATE OF DYE MOLECULES.

A.Bączyński and M.Czajkowski.

Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys., Vol. 7, No. 6, 357-60 (1959).

Measurements are made of the ratio of phosphorescence to fluorescence yields versus concentration of fluorescein and of acid solution. Results show that the metastable state thus revealed is a characteristic of single dye molecules and is not due to molecular association (e.g. dimerization) as proposed by Williams (Abstr. 2976 of 1958). G.F.J.Garlick

532.7 : 535.37

### 3538 A NEW TYPE OF FLUOROMETER-MEASUREMENTS OF DECAY PERIODS OF FLUORESCENCE OF ACRIDINE YELLOW SOLUTIONS AS A FUNCTION OF CONCENTRATION.

R.Bauer and M.Rozwadowski.

Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys., Vol. 7, No. 6, 365-8 (1959).

Earlier types of fluorometers measuring phase differences between the modulated exciting light and the fluorescence are briefly described. To improve the low luminosity in instruments using light diffraction, birefringence in a block of fused quartz between crossed Nicols is now used, with a piezo-quartz crystal excited at 5530 kc/s. Light modulation in the block is at twice this frequency, making the ultraviolet region accessible. Part of the modulated light traverses a variable path length to a photomultiplier, and the other part reaches a second photomultiplier via a scatterer or alternatively a fluorescent substance. The variable path is adjusted to give no phase difference in the receiver in each case, and the path length difference is then proportional to the mean fluorescence emission time. In boric acid solution acridine yellow gave times of $\sim 10^{-8}$ sec, with a maximum time at a concentration of $\sim$ 0.025%. S.T.Henderson

532.7 : 535.37

### 3539 TEMPERATURE DEPENDENCE OF FLUORESCENCE BANDS OF URANYL NITRATE SOLUTIONS.

D.D.Pant, D.P.Khandelwal and H.D.Bist.

Curr. Sci., Vol. 28, No. 12, 483-4 (Dec., 1959).

The emission spectra of uranyl nitrate solutions of a given pH and concentration depend not only on temperature but also on previous thermal treatment. Spectra are given at various temperatures of solutions which had been cooled and heated at various rates. J.Franks

532.7 : 535.37

### 3540 LUMINESCENCE AND VAVILOV–CHERENKOV RADIATION IN SOLUTIONS ACTED UPON BY $\gamma$-RAYS.

Z.A.Chizhikova.

Optika i Spektrosk., Vol. 7, No. 2, 223-30 (Aug., 1959). In Russian.

Reports studies of the relationships between $\gamma$-luminescence and Vavilov–Cherenkov radiation in solutions in which there is no transfer of energy between the solute and the solvent (water, ethyl alcohol, acetone, etc.). From this relationship the efficiency $\rho$ of excitation of luminescence by fast electrons is deduced ($\gamma$-ray energy is absorbed in solutions via Compton electrons). The followin solutions were studied: sodium salicylate in water, quinine sulphide in water with 0.3% of $H_2SO_4$, 3 aminophthalimide in ethyl alcohol, 2,5 diphenyloxazole in ethyl alcohol, 2,5 diphenyloxasole in acetone, and anthracene in acetone. The values of $\rho$ found by the author were 3.3-4.7%. A.Tybulewicz

532.7 : 535.37 : 621.315.615.2

### 3541 LUMINOUS SPOTS ON ELECTRODES IN INSULATING OIL GAPS.

T.W.Dakin and D.Berg.

Nature (London), Vol. 184, 120 (July 11, 1959).

These spots, which had been seen before, were re-examined with more refined techniques. They occurred only at the negative electrode with d.c. stresses in well-filtered degassed oil. They are attributed to fluorescence of oil molecules excited by field-emitted electrons from points of locally high stress on the electrodes The threshold stress was of the order of 50-250 kV/cm. This suggests the origin of gas development in stressed oils, since the 4 eV for decomposition of the molecules is not much greater than the 3 eV for fluorescence. I.D.L.Ball

532.7 : 535.56

### 3542 OPTICAL ACTIVITY AND INTERMOLECULAR INTERACTION.

V.M.Aslanyan and M.V.Vol'kenshtein.

Optika i Spektrosk.,Vol. 7, No. 2, 208-16 (Aug., 1959). In Russian.

Quantum-mechanical effects have to be taken into account when optical activities of concentrated solutions and pure liquids are discussed, since in this case resonance interaction is important. The theory of optical activity presented is based on the valence-optical scheme with tensors of polarizability ascribed to individual bonds and groups of atoms in a molecule. Optical activity is then the result of induction-type interaction of groups which are asymmetrically distributed and anisotropically polarized. The theory is compared with experimental results and good agreement is reported. A.Tybulewicz

532.7 : 535.56

### 3543 EXPERIMENTAL RESEARCHES ON MAGNETIC ROTARY POWER AND THE ROTATIVITY OF FLUIDS.

J.Grange.

Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 1-2, 47-88 (Jan.-Feb., 1959). In French.

A detailed account is given of experiments made to determine the specific rotary power, the specific rotativity and the molecular rotativity of a number of substances in both the gaseous and liquid forms. The apparatus is described together with the relevant theory and a table of results given. They include values for argon, krypton, xenon, hydrogen, oxygen, nitrogen, air, carbon dioxide, sulphur dioxide, hydrogen sulphide, carbon disulphide, nitric oxide, methane, ethane, propane, butane, n-pentane, isopentane, hexane, ethylene, propene, butene, butadiene, pentene, isoprene, cyclohexene, benzene, methyl alcohol, ethyl alcohol, ethyl ether, acetone, methyl-ethyl-ketone, methyl chloride, ethyl chloride, chloroform, carbon tetrachloride, methyl bromide, furan, tetrahydrofuran, acetonitrile and proprionitrile. It is concluded that the specific rotation of a gas away from the critical state is sensibly constant; the specific rotation of the liquid is in all cases much greater than that of the gas, whereas the latter differs only relatively little from the rotativity of the liquid; the magnetic rotary dispersion of the gas and the liquid are sensibly identical. 50 references are given.

H.G.Jerrard

532.7 : 538.27

### 3544 HYPERFINE STRUCTURE OF DISSOLVED COPPER IONS IN PARAMAGNETIC RESONANCE.

E.Lutze and D.Bösnecker.

Z. Naturforsch, Vol. 14a, No. 8, 755-8 (Aug., 1959). In German.

Observation of hyperfine structure in solutions of $CuSO_4.5H_2O$, $CuSO_4$ and $Cu(NH_3)_4SO_4$ in glycerol at 300 and at 90°K for various concentrations. Splitting due to the Cu nucleus is weakly observed. Line width variation with concentration confirm exchange narrowing. The nature of the bonding to copper ion is discussed.

J.G.Powles

532.7 : 538.27

### 3545 OVERHAUSER EFFECT IN ASPHALT SOLUTIONS.

E.H.Poindexter.

J. chem. Phys., Vol. 31, No. 6, 1477-80 (Dec., 1959).

It was found that solutions of asphalt in a suitable solvent will show an Overhauser effect. The effect is qualitatively similar to that in crude oil. It arises from a dipolar interaction between the unpaired spins in the asphaltic free radicals, and the protons of the solvent molecules. The contribution to proton relaxation from the asphalt is a linear function of asphalt concentration. The function relating proton signal enhancement to electron saturating r.f. field strength is found to vary with asphalt concentration. A plot of enhancement versus electron-stimulating frequency at constant $H_0$ yields a curve similar to e.p.r. absorption line. The large size of the asphalt radicals does not appear to have any direct significance with respect to the Overhauser interaction.

532.7 : 538.27

### 3546 NUCLEAR MAGNETIC RESONANCE STUDIES ON HYDRATION OF CATIONS.

J.A.Jackson, J.F.Lemons and H.Taube.

J. chem. Phys., Vol. 32, No. 2, 553-5 (Feb., 1960).

A preliminary study of the $O^{17}$ n.m.r. spectra of aqueous solutions has shown that it is possible to distinguish solvent water from water in the hydration sphere of certain cations. For certain ions the hydration water of which is sufficiently nonlabile (lifetime for exchange $>10^{-4}$ sec), it is possible to display the hydration water as a separate n.m.r. peak when the solvent peak is shifted by addition of a paramagnetic ion. A method is suggested for determining the hydration number of such cations by measuring the change in the water available to interact with the paramagnetic ions due to water retained in the hydration sphere of the cations. The enrichment level of the $O^{17}$ at present available does not permit precise determination of the hydration number, but the results are not incompatible with reasonable values.

532.7 : 538.27 : 539.2

NUCLEAR MAGNETIC RESONANCE ABSORPTION IN ISOBUTYL BROMIDE AS A SUPERCOOLED LIQUID. See Abstr. 3139

532.7 : 538.27

### 3547 IONIZATION OF STRONG ELECTROLYTES. VIII. TEMPERATURE COEFFICIENT OF DISSOCIATION OF STRONG ACIDS BY PROTON MAGNETIC RESONANCE.

G.C.Hood and C.A.Reilly.

J. chem. Phys., Vol. 32, No. 1, 127-30 (Jan., 1960).

For previous parts see Abstr. 3539-40 (1958). The proton magnetic resonance of nitric and perchloric acid solutions over the entire concentration range was used for determining the dissociation constants at 0, 25, and 70°C. Excellent agreement with earlier data for nitric acid derived from Raman spectra was obtained.

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## MECHANICS OF GASES

533.4

### 3548 A PISTON MANOMETER [WORKING] TO 20 000 ATMOSPHERES.

M.K.Zhokovskii, Yu.S.Konyaev and V.G.Levchenko.

Pribory i Tekh. Eksper., 1959, No. 3, 118-22 (May - June). In Russian.

A detailed drawing and description of the manometer are given, including specifications of the materials of construction and the working fluid. Tests of the manometer have been carried out using a special assembly for the creation and accurate measurement of pressures up to 20 000 atmospheres. The dependence of piston velocity on pressure is determined and shows a maximum at about 3000 kg/cm$^2$. The theory of the manometer is developed.

R.F.S.Hearmon

533.4

### 3549 A CONVECTION MANOMETER.

M.T.Dmitriev.

Pribory i Tekh. Eksper., 1959, No. 3, 148-9 (May-June). In Russian.

The measurement of gas pressure by convectional heat transfer is discussed and a theoretical equation derived for the pressure. A convection manometer, working between 0.5 and 1000 mm Hg, is suggested, based on a particular manometric valve (LT2). Calibration curves are given for the valve and show good agreement with the theoretical formula. See also Abstr. 4859 of 1956.

R.F.S.Hearmon

533.4

### 3550 HIGH-SENSITIVITY PRESSURE GAUGE COUPLING TWO SPOON GAUGES.

R.R.Monchamp, E.Bannister and F.A.Cotton.

Rev. sci. Instrum., Vol. 30, No. 10, 945-6 (Oct., 1959).

Describes how two spoon gauges may be coupled to give high sensitivity whilst retaining the desirable qualities of this type.

E.G.Knowles

533.4

### 3551 GREASELESS MERCURY CUTOFF FOR DIFFERENTIAL PRESSURE OPERATION.

G.H.Miller, G.O.Pritchard and M.Weston.

Rev. sci. Instrum., Vol. 30, No. 10, 948-9 (Oct., 1959).

The note outlines the construction of a cutoff. E.G.Knowles

533.6

### 3552 AIRFOIL IN A SONIC SHEAR FLOW JET: A MIXED BOUNDARY VALUE PROBLEM FOR THE GENERALIZED TRICOMI EQUATION.

C.C.Chang and T.S.Lundgren.

Quart. appl. Math., Vol. 17, No. 4, 375-92 (Jan., 1960).

Small perturbations of a nonuniform two-dimensional flow of a compressible inviscid fluid are considered. It is shown that for a particular class of main stream Mach number distributions, which are characterized by a sonic line along the x-axis, the linearized shear flow equation may be transformed into the generalized Tricomi equation. The mixed boundary value problem which results from considering perturbations generated by a two-dimensional camber surface is formulated and solved by utilizing the Wiener—Hopf technique.

533.6

### 3553 COMPRESSIBLE TURBULENT BOUNDARY LAYERS WITH HEAT TRANSFER AND PRESSURE GRADIENT IN FLOW DIRECTION.

A.Walz.

J. Res. Nat. Bur. Stand., Vol. 63B, No. 1, 53-70 (July-Sept., 1959).

The best-known theoretical works on boundary-layer problems, especially in the case of compressible flow without or with heat transfer, are related to the laminar boundary layer, although the turbulent boundary layer is, in practice, often more interesting. The laminar boundary layer is more easily accessible to theoretical treatment because clearly defined relations exist between the viscosity $\mu$ and the shear stresses $\tau$. In the turbulent case, empirical relations must be introduced. Therefore, attempts to get exact solutions are not worthwhile, while efforts to obtain approximate solutions, based for instance on the von Karman—Pohlhausen principle of utilizing integral conditions, appear to be appropriate to this problem. In the last few years the accuracy of such approximate solutions for the incompressible case was noticeably improved by the application of a new energy integral condition in connection with a new empirical law for the dissipation in turbulent boundary layers, stated by Rotta and Truckenbrodt. The empirical laws for dissipation and for turbulent wall friction, which are needed in the present approximate theory, are formulated on the basis of available measurements for incompressible flow. Generalization to the compressible flow with heat transfer is made from physical considerations. Calculated results agree satisfactorily with available experimental data. Some possibilities for improving as well as for simplifying the approximation theory is outlined.

533.6 : 577.3

### 3554 DEVICE FOR THE ESTIMATION OF THE RATE OF WORK ON PASSING AIR BY SINE WAVE FLOW.

E.A.Cooper.

J.sci. Instrum., Vol. 36, No.10, 436-8 (Oct., 1959).

In investigating the resistance to airflow of equipment for respiratory protection, it is often desirable to know the rate of work done in sine wave flow. A device is described which allows this estimation to be made without intermediate calculation from the results of simple experiments carried out under conditions of constant rates of flow. If these results, when plotted on logarithmic paper as pressure against rate of flow, lie on a straight line, the device allows a second line to be drawn which represents the rate of work done in sine wave flow plotted against the volume moved per minute.

533.6 : 536.46

### A STUDY OF COMBUSTION IN SUPERSONIC FLOW.

See Abstr. 2270

## GASEOUS STATE

533.7

### 3555 SOME ASPECTS OF MOLECULAR PHYSICS.

J.M.H.Levelt.

Amer. J. Phys., Vol. 28, No. 3, 192-6 (March, 1960).

It is shown how the results of compressibility measurements in gases and liquids lead to the hypothesis of molecular interaction, and how details about this interaction may be obtained from the experimental data for the equation of state. The reasons for the molecular interaction are found in the laws of electrostatics and quantum mechanics. The problems the molecular physicist is interested in are threefold. He wants to understand molecular interaction from first principles, he tries to get information about this interaction from a variety of experiments, and he seeks to understand a large group of experimental observations once the interaction of the molecules is known. For the solution of the second and third problem it is usually necessary to link the macroscopic observables to the microscopic molecular properties; although this has been possible in some instances, the general problem cannot be solved.

533.7

### 3556 APPROXIMATIONS TO THE EQUATION OF STATE OF A FERMI–DIRAC GAS. H.A.Buchdahl.

Ann. Phys. (Leipzig), (Folge 7), Vol. 3, No. 7-8, 345-51 (1959).

In German.

If the equation of state is written in the form

$$[PV/NkT] = f(x)$$

where

$$x = N\,h^3/[4\pi(2mkT)^{3/2}V]$$

the function f is known in the form of expansions for small and for large values of x, whereas its evaluation in intermediate ranges is cumbersome. The author puts forward the formula

$$f(x) = [1 + ax + b\,x^{13/6} + c\,x^{7/2}]^{4/21}$$

where a = 1.04722, b = 0.423247 and c = 0.0336616. This formula approaches the correct expansions in the limits of small and of large values of x and interpolates in the intermediate range with an error of fractions of a percent. R.Eisenschitz

533.7

### 3557 THE PROBABILITY DISTRIBUTION OF THE VELOCITIES OF GAS MOLECULES AFTER COLLISION WITH A RAPIDLY MOVING RIGID BODY. P.Beckmann.

Czech. J. Phys., Vol. 9, No. 5, 557-61 (1959).

533.7

### 3558 KINETIC THEORY OF NONSPHERICAL MOLECULES. IV. ANGULAR MOMENTUM TRANSPORT COEFFICIEN

P.M.Livingston and C.F.Curtiss.

J. chem. Phys., Vol. 31, No. 6, 1643-5 (Dec., 1959).

The kinetic theory of nonspherical molecules, as developed earlier, leads to an expression for the flux of angular momentum, involving several new transport coefficients. This paper is concerned with the evaluation of the first of these coefficients, $L^{(0)}$. The expression for this quantity as given earlier, is simplified by carrying out certain integrations explicitly. The resulting expressio depends directly only upon the geometry of the molecular model. As an example, the spherocylinder is considered. The final integrations are then carried out analytically. The resulting expression for the dimensionless transport coefficient depends only upon three dimensionless groups of parameters characterizing the shape and mass distribution. The numerical results are illustrated graphically.

533.7 : 539.18

### 3559 AN APPLICATION OF THE KINETIC THEORY OF GASES TO THE STUDY OF THE SPECTRAL NATURE OF AN EMISSION. H.Triché.

C.R. Acad. Sci. (Paris), Vol. 248, No. 19, 2743-5 (May 11, 1959).

In French.

The mean power radiated per atom of a gas can be defined by the kinetic theory. As the temperature of a gas becomes very high its kinetic energy remains constant and energy is radiated. At a given temperature an easily excited atom radiates more energy per second than an atom less easily excited. For a given gas the radiated energy available increases with temperature. To obtain a high temperature either the power of the source must be increased or the number of atoms in the source decreased. It is concluded that the power available per atom of a gas depends on the ionization potential of the atom, the kinetic energy of the gas and the number of collisions. In a source containing two different kinds of atoms the ratio of the radiated energies is independent of temperature and depends only on the nature of the atoms. The results of King, [Proceedings of the Sixth International Conference on Spectroscopy, Amsterdam (1957), 152-61] approximate to this theory. J.S.Young

533.7

### 3560 EMPIRICAL INTERMOLECULAR POTENTIAL FOR INERT GAS ATOMS. W.W.Woolley.

J. chem. Phys., Vol. 32, No. 2, 405-9 (Feb., 1960).

Transport and thermodynamic calculations for gases at high temperature call for reliable interaction potentials at close approach Potentials for the noble gases can be extrapolated approximately, yet with some reliability, from the empirical fit of properties in the ordinary range, using a screened Coulomb repulsion and a dispersion attraction reduced by a suitable factor at close approach. Parameters for this potential can be obtained approximately from the known parameters for the exp-six potential. The resulting empirical coefficient for the Coulomb term is found to be of the general order of magnitude given by the product of the nuclear charges. If the theoretical Coulomb repulsion is used, the screening exponent may alternatively be chosen on the basis of other empirical parameters.

533.7

### 3561 INITIAL PRESSURE DEPENDENCE OF THERMAL CONDUCTIVITY AND VISCOSITY.

D.E.Stogryn and J.O.Hirschfelder.

J. chem. Phys., Vol. 31, No. 6, 1545-54 (Dec., 1959).

The initial pressure dependence of thermal conductivity and viscosity of gases is considered to arise from molecular association and collisional transfer. Since only the initial pressure dependence is investigated, clusters larger than dimers can be neglected. The effect of dimer formation can be calculated from a knowledge of the equilibrium constant for the reaction $2A \rightleftharpoons A_2$. The effect of collisional transfer is obtained by a semiempirical modification of Enskog' Enskog's theory. In the case of thermal conductivity, it is found that at low temperatures molecular association is more important than collisional transfer, while at high temperatures collisional transfer predominates. For viscosity, the initial pressure dependence is due primarily to collisional transfer. Detailed equations for the initial pressure dependence of both thermal conductivity and viscosity are given in terms of dimensionless groupings which include the intermolecular potential parameters. Tables of these dimensionless groupings as functions of a reduced temperature are given for molecules obeying the Lennard-Jones (6-12) potential. Comparisons between theory and experiment are included. It is found that the numerical results are sensitive to the choice of force constants for the interaction of a monomer with a dimer.

533.7

### 3562 THERMAL CONDUCTIVITY OF BINARY MIXTURES OF DIATOMIC AND MONATOMIC GASES.

B.N.Srivastava and A.K.Barua.

J. chem. Phys., Vol. 32, No. 2, 427-35 (Feb., 1960).

Thermal conductivity of the binary mixtures of $O_2$–He, $O_2$–Ne, $O_2$–Kr, and $O_2$–Xe were measured at 30° C and 45° C for various compositions by using the thick-wire-variant of the hot-wire method. For pure $O_2$ the experimental value of the thermal conductivity is lower than that given by the recent theory of Hirschfelder based on the assumption of local chemical equilibrium, and consequently the values calculated from Hirschfelder's formula for the mixture conductivities are also expected to be higher than the experimental values which is actually found to be so for the mixtures investigated here. The agreement becomes excellent when the experimental values of the conductivity of pure $O_2$ are used to calculate the mixture conductivities. The formula for the mixture conductivities has been tested in detail and was found to give satisfactorily the composition dependence. The simpler formula for the thermal conductivity of gas mixtures given by Mason and Saxena has also been tested.

533.7

### 3563 MOLECULAR DIFFUSION STUDIES IN GASES AT HIGH TEMPERATURE. IV. RESULTS AND INTERPRETATION OF THE $CO_2$–$O_2$, $CH_4$–$O_2$, $H_2$–$O_2$, CO–$O_2$, AND $H_2O$–$O_2$ SYSTEMS.

R.E.Walker and A.A.Westenberg.

J. chem. Phys., Vol. 32, No. 2, 436-42 (Feb., 1960).

Experimental measurements of the binary diffusion coefficients for the $CO_2$–$O_2$, $CH_4$–$O_2$, $H_2$–$O_2$, CO–$O_2$, and $H_2O$–$O_2$ systems over the nominal temperature range 300-1000° K are reported. The measurements were made by the point source technique. The data have been analysed in terms of intermolecular potential energies and the rigorous kinetic theory by using the Lennard–Jones (12-6), modified Buckingham (exp-6), point centre of repulsion (inverse power), and the exponential repulsion potential energy functions. It is shown that all four of these functions are capable of fitting the diffusion data with about the same precision (within experimental error). However, the potential energy values themselves which are calculated from these four different fitted models are shown to be widely at variance; especially in the range of interaction corresponding to the lower temperatures. Thus, these results provide an example of the high degree of ambiguity (previously noted by several others) involved in deducing intermolecular potential energies from transport data. The use of such fitted potentials to extrapolate transport data to higher temperatures, on the other hand, is probably a more reliable procedure, and diffusion coefficients for the above five gas pairs (in their unexcited, undissociated states) have been estimated to 3000° K from the potentials based on the 300-1000° K measurements.

533.7 : 534.22

### 3564 PHYSICAL INVESTIGATION OF GASES BY MEANS OF SHOCK WAVES.

R.I.Soloukhin.

Uspekhi fiz. Nauk, Vol. 68, No. 3, 513-28 (June, 1959). In Russian.

A review dealing with: choice of method for producing and using shock waves; thermodynamic properties of air and other gases at high temperatures; propagation of shock waves in relaxing gases; investigation of chemical reactions in gases at a shock wave; spectroscopic investigation of the gas state at a shock wave; thermodynamic equilibrium on ionization at a shock wave. 52 references. R.F.S.Hearmon

533.7 : 539.18

### 3565 LOW-TEMPERATURE, LOW-PRESSURE TRANSPORT COEFFICIENTS FOR GASEOUS OXYGEN AND SULFUR ATOMS.

D.D.Konowalow, J.O.Hirschfelder and B.Linder.

J. chem. Phys., Vol. 31, No. 6, 1575-9 (Dec., 1959).

The transport properties of a gas at low temperature can be estimated in terms of the potential energy curves at very large separations. For this purpose it is only necessary to know the dispersion and multipole energies of interaction. Such calculations are carried out for the interaction of two oxygen or two sulphur atoms in their ground states. The atoms have an a priori probability $p_i$ of interacting in accordance with one of a set of potential energy functions $\phi_i(R)$, where $p_i$ is proportional to the sum of the degeneracies of the states of the collision complex to which $\phi_i(R)$ applies. For such collisional problems involving more than one potential energy function, the collision cross-section Q for any process is rigorously additive in the sense that $Q = \Sigma_i p_i Q_i$, where $Q_i$ is the collision cross-section considering only the i-th potential.

533.7 : 539.19

### 3566 MASS SPECTROMETRIC AND THERMODYNAMIC STUDY OF GASEOUS TRANSITION METAL (II) HALIDES.

R.C.Schoonmaker, A.H.Friedman and R.F.Porter.

J. chem. Phys., Vol. 31, No. 6, 1586-9 (Dec., 1959).

Mass spectrometric and Knudsen effusion techniques were used to study the vaporization of several transition metal (II) halides. The systems studied include $FeI_2$ and the chlorides and bromides of Cr, Mn, Co, and Ni. The over-all temperature range was between 440 and 700° C. For all systems the monomer is the major vapour species in the temperature range studied. Dimeric species have also been detected in the vapour phase for all systems, except $NiCl_2$ and $NiBr_2$. Vapour pressure data were combined with mass spectrometric and entropy data to give heats for the dimerization reaction $2MX_2(g) = M_2X_4(g)$.

533.7 : 539.19

### 3567 CONTRIBUTION OF BOUND, METASTABLE, AND FREE MOLECULES TO THE SECOND VIRIAL COEFFICIENT AND SOME PROPERTIES OF DOUBLE MOLECULES.

D.E.Stogryn and J.O.Hirschfelder.

J. chem. Phys., Vol. 31, No. 6, 1531-45 (Dec., 1959).

The second virial coefficient for molecules interacting with a spherically symmetric potential is divided into three parts: (1) a contribution $B_b$, related to the equilibrium constant for the formation of bound double molecules; (2) a contribution $B_m$, related to the equilibrium constant for the formation of metastably-bound double molecules; and (3) a contribution $B_f$, due to molecules which interact but are free to separate after the interaction. Equations are given for determining each of the three parts of the second virial coefficient. A detailed treatment of these three contributions together with numerical tables on a reduced temperature basis is given for the square-well, Sutherland, and Lennard-Jones (6-12) potentials. The mean lifetimes of metastably bound double molecules are discussed, and numerical values are given for the special case of argon. Tables for computing mean lifetimes in other Lennard-Jones gases are given. It is found that most metastably bound double molecules have mean lifetimes considerably longer than the mean time between collisions at ordinary pressures. Finally, an equation is developed for the number of vibrational levels of a double molecule.

533.7 : 535.33

### 3568 INVESTIGATION OF THE TEMPERATURE DEPENDENCE OF THE INFRARED ABSORPTION BAND INTENSITY IN GASES.

V.N.Smirnov and P.A.Bazhulin.

Optika i Spektrosk., Vol. 7, No. 2, 193-201 (Aug., 1959). In Russian.

The temperature dependence of the infrared absorption intensity of the following substances in gaseous form was determined: acetone, methyl iodide, chloroform, cyclopentane, $C_2Cl_4$, $CS_2$, $CCl_4$, $CH_4$, NO, CO, HCl. For the majority of bands the intensity increases with temperature but this increase is often higher than that predicted by a statistical theory. The main reason for these discrepancies lies in intermolecular interactions (collisions). It was also found that with increase of pressure the intensities of the majority of the bands increase, but the effect of pressure is smaller than the effect of temperature. A.Tybulewicz

## VACUUM PHYSICS

533.5

### 3569 A NEW DESIGN OF MECHANICAL VACUUM PUMP.

A.Lorenz.

Vide, Vol. 14, 121-7 (May-June, 1959). In French.

Describes a rotary piston pump in which the rotor is mechanically balanced. By the use of a few basic piston units a range of seven pumps may be built up. Performance curves are given. T.Mulvey

533.5

### 3570 A NEW CONSTRUCTION OF A HIGH-VACUUM HIGH-SPEED ION PUMP.

L.Pátý and R.Neužilová.

Czech. J. Phys., Vol. 8, No. 6, 746-7 (1958).

The details of design of an ion pump utilizing a discharge in an axial magnetic field are given. The proportion of the pumping which is due to adsorption was obtained for three values of the magnetic field strength over a range of gas pressures. J.Dutton

533.5

3571 EVAPOR-ION PUMP [WITH LIQUID HELIUM TRAP]. D.A.Degras.

Vide, Vol. 14, 128-40 (May-June,1959). In French.

Describes in some detail the development of an evaporation pump using titanium wire, fed continuously onto a hot crucible. A helium trap is used to complete the pumping. The speed is 1500 litres/sec for air and 2000 litres/sec for hydrogen. T.Mulvey

533.5

3572 A NOTE ON THE PAPER "THE OXIDATION OF EVAPORATED BARIUM FILMS (GETTERS)".

S.J.Gregg and W.B.Jepson, with reply by R.N.Bloomer.

J. sci. Instrum., Vol. 9, No. 10, 417-18, 418-19 (Oct., 1958).

For original paper, see Abstr. 9037 of 1957.

533.5 : 621.385.832

3573 TITANIUM AS A GETTERING MATERIAL. R.L.Stow.

Nature (London), Vol. 184, 542-3 (Aug. 15, 1959).

Describes the use of titanium as a getter in cathode ray tubes. With barium getters ultimate pressures of $10^{-6}$ mm Hg were recorded but these were improved to $2 \times 10^{-8}$ mm Hg by using titanium. The ion gauge was run continuously during both sets of measurements. A.E.I.Research Laboratory

533.5

3574 SIMPLE DEMOUNTABLE INDIUM O-RING SEAL, TIGHT TO He II. H.Seki.

Rev. sci. Instrum., Vol. 30, No. 10, 944-5 (Oct., 1959).

Using $\frac{1}{16}$ in. indium wire, the overlapping ends are joined by the applied pressure to form the O-ring. A new ring has to be inserted each time the seal is dismounted. A.H.W.Beck

533.5

3575 ULTRAHIGH-VACUUM VALVE. N.N.Axelrod.

Rev. sci. Instrum., Vol. 30, No. 10, 944-5 (Oct., 1959).

Describes valves in which an iron slug is pulled downwards into molten indium. The rise in level of the indium surface then closes the valve when the indium freezes. A.H.W.Beck

533.5

3576 METAL BAKEOUT VALVE FOR ULTRAHIGH VACUUM. C.M.Haaland.

Rev. sci. Instrum., Vol. 30, No. 10, 947-8 (Oct., 1959).

Describes a mechanically operated valve which is sealed by a reservoir of molten tin. By the use of a tin-retaining lip on the moving element, a reliable joint can be ensured. A.H.W.Beck

533.5

3577 MAGNETICALLY DRIVEN FAST-ACTING VALVE FOR GAS INJECTION INTO HIGH VACUA.

B.Gorowitz, K.Moses and P.Gloersen.

Rev. sci. Instrum., Vol. 31, No. 2, 146-8 (Feb., 1960).

A description is given of a valve suitable for use in studies involving the acceleration of plasmas into regions of high vacua. Valve opening durations of less than 60 $\mu$sec may be attained, and amounts of gas lower than 0.01 cm$^3$ s.t.p. may be introduced. Valve performance characteristics and measuring techniques are discussed.

533.5

3578 THE CLEANING OF GLASS IN A GLOW DISCHARGE. L.Holland.

Brit. J. appl. Phys., Vol. 9, No. 10, 410-15 (Oct., 1958).

The cleanliness of the treated glasses is assessed by their coefficient of friction $\mu$, freedom from optical absorption and wetting characteristics. Glasses bombarded by high energy electrons from the cathode dark space in the presence of hydrocarbon vapours are coated with organic layers, whereas glasses bombarded in the positive column are cleaned. Deposits formed in hydrocarbon vapours have a value of $\mu = 0.3$ and cannot be wetted, whereas those formed in silicone vapour are wettable and have a value of $\mu = 0.6$. An electrode system is described for use in evaporating plant in which the high energy electrons traversing the cathode dark space are prevented from bombarding the glass. Random bombardment by positive ions and neutral molecules in air, A, $N_2$, $H_2$ and $O_2$ produces clean glass with $\mu = 0.7$-$0.9$. The contamination of the cleaned surfaces by hydrocarbon and silicone molecules is discussed. Freshly deposited silica films and glass surfaces prepared by fracture in vacuo become contaminated by strongly adsorbed silicone molecules whereas clean aged surfaces of glass and silica are not contaminated because the cations are screened by OH ions.

533.5

3579 LIQUID HELIUM TRAP FOR HIGH PUMPING SPEED AT LOW PRESSURES. H.L.Caswell.

Rev. sci. Instrum., Vol. 30, No. 11, 1054-5 (Nov., 1959).

Describes a liquid helium thimble trap for use in evaporation systems in the $10^{-9}$ Torr range. The trap is located in the evaporation chamber and external cooling with liquid nitrogen is used to minimize the loss of helium. A.H.W.Beck

533.5 : 537.54

PUMPING OF LINEAR ACCELERATORS. See Abstr. 2407

## VIBRATIONS · ACOUSTICS

534.13

3580 THE INFLUENCE OF SHEAR AND ROTATORY INERTIA ON THE FREE FLEXURAL VIBRATION OF WOODEN BEAMS. R.F.Hearmon.

Brit. J. appl. Phys., Vol. 9, No. 10, 381-8 (Oct., 1958).

The existence of shear and rotatory inertia effects leads to a reduction in the frequency of flexural vibration of beams as compared with the frequencies predicted by the simple Rayleigh treatment. Tables and graphs, based on the Timoshenko—Goens theory, are given to facilitate the estimation of the correction factor in the case of free—free beams. Experiments are described in which the frequencies of wooden beams are measured up to the 16th mode, and a least-squares method is described for analysing the results. Effects introduced by the anisotropic nature of wood are also investigated and discussed.

534.13 : 532.5

ACOUSTIC IMPEDANCE OF VISCOELASTIC MEDIUM BETWEE PARALLEL PLATES. See Abstr. 3502

534.15

3581 VIBRATION AMPLITUDE METER USING MOIRÉ-FRINGE TECHNIQUE.

T.W.Aitchison, J.W.Bruce and D.S.Winning.

J. sci. Instrum., Vol. 36, No. 9, 400-2 (Sept., 1959).

It is used for the measurement of vibration amplitudes at frequencies below 50 c/s and for the calibration of other transducers. Because its frequency range extends down to zero, the instrument can be used to detect and measure small displacements.

534.21

3582 SOME QUESTIONS OF PROPAGATION OF FINITE AMPLITUDE ULTRASONIC WAVES IN LIQUIDS.

L.K.Zarembo and V.A.Krasil'nikov.

Uspekhi fiz. Nauk, Vol. 68, No. 4, 687-715 (Aug., 1959). In Russian.

A review of theoretical and experimental results for the distortion and absorption of the waves. R.F.S.Hearmon

534.22

3583 PRESSURE SENSING PROBES FOR DETECTING SHOCK WAVES. A.B.Amster and R.L.Beauregard.

Rev. sci. Instrum., Vol. 30, No. 10, 942 (Oct., 1959).

The passage of a shock wave is detected by a probe which closes an electric circuit. Closure occurs when a pressure greater than 12 000 p.s.i. acting on the probe, collapses a thin walled copper tube on to a copper wire. The response time is of the order of $10^{-7}$ seconds. E.R.Wooding

534.22

3584 CONTINUOUS OSCILLOGRAPHIC METHOD FOR MEASURING THE VELOCITY AND CONDUCTIVITY OF STABLE AND TRANSIENT SHOCKS IN SOLID CAST EXPLOSIVES.

A.B.Amster, P.A.Kendall, L.J.Veillette and B.Harrell.

Rev. sci. Instrum., Vol. 31, No. 2, 188-92 (Feb., 1960).

The continuous monitoring of the position and relative conductivity of reactive shock waves in confined cast explosives is made possible by a new technique. A fine Nichrome wire is cast within and parallel to the long axis of the sample. A record of its resistance during detonation serves to locate the ionization front associated with detonation. The measurement is recorded on an oscillograph. From the photograph of this record, instantaneous detonation velocities are measured to within ± 2%. Attenuation of the initiating shock causes a delay in the establishment of a stable detonation in the acceptor. The distance and time required for this transition in confined charges can be measured. The simultaneous use of independent Nichrome and copper wire sensors furnishes additional information about the conductivity of the predetonation zone. Failure of a propagating detonation can also be studied; this permits the measurement of critical diameters, i.e., that diameter below which detonation will not propagate in an unconfined charge. Examples of each use are presented.

534.22

3585 SHOCK ADIABATICS IN MARBLE.
A.N.Dremin and G.A.Adadurov.
Dokl. Akad. Nauk SSSR, Vol. 128, No. 2, 261-4 (Sept. 11, 1959). In Russian.

The authors describe measurements of the parameters of shock waves (mass and wave velocities, densities and pressures) passing from aluminium to marble specimens. The observed mass velocity/wave velocity graph shows a discontinuity due to a phase transition, when the shock wave configuration changes abruptly. This phase transition exhibits the usual kink on the adiabatic of marble.

J.K.Skwirzynski

534.22 : 533.7

PHYSICAL INVESTIGATION OF GASES BY MEANS OF SHOCK WAVES. See Abstr. 3564

534.22 : 536.53

THIN-FILM THERMOMETER MEASUREMENTS IN PARTIALLY IONIZED SHOCK-TUBE FLOWS. See Abstr. 2274

534.23

3586 SINUSOIDAL PRESSURE GENERATOR WITH WIDE AMPLITUDE AND FREQUENCY RANGES.
T.A.Perls, D.O.Miles and L.B.Wilner.
J. Acoust. Soc. Amer., Vol. 32, No. 2, 274-81 (Feb., 1960).

Design considerations are given for a sinusoidal pressure generator (S.P.G.) capable of providing sinusoidal pressures up to 26 atm peak to peak, proportional to input voltage to within 5% over the frequency range from 0 to 10 000 c/s. The pressure is generated in a fluid contained in a relatively rigid metal enclosure, by means of a stack of 24 disks of a piezoelectric ceramic, connected electrically in parallel, and arranged so that their displacements add. Several applications of the S.P.G. are discussed including several types of evaluation tests for pressure gauges, evaluation of electromechanical drivers, tests of piezoelectric materials near zero frequency, and study of frequency-dependent effects in liquids. Preliminary relaxation data are shown for two associated liquids, diphenyl metachloride (Aroclor No. 1260) and glycerol.

534.23 : 532.5

3587 HYDRAULIC OSCILLATOR FOR THE DYNAMIC CALIBRATION OF PRESSURE RECORDING SYSTEMS.
A.W.Melville.
J. sci. Instrum., Vol. 36, No. 10, 422-4 (Oct., 1959).

The instrument provides a constant-amplitude variable-frequency pressure cycle in a liquid, suitable for the determination of the frequency response of precision pressure transducers of low volume displacment. The natural frequency of the fluid filled oscillator is 630 c/s.

534.23

3588 ON THE CLASS OF "RECIPROCITY METHODS".
G.B.Madella.
J. Acoust. Soc. Amer., Vol. 32, No. 2, 282 (Feb., 1960).

In addition to the so-called "Reciprocity Methods" for calibrating electroacoustic transducers, other methods are also based upon the reciprocity principle. It is therefore suggested that, at least in theoretical treatments, the modern methods be quoted as a particular form of the more general class of reciprocity techniques.

534.23 : 535.42

GENERATING TWO U.S. WAVES WITH CONTINUOUSLY VARIABLE PHASE DIFFERENCE. APPLICATION TO LIGHT DIFFRACTION. See Abstr. 2254

534.26 : 538.56

DIFFRACTION BY A SPHEROID. See Abstr. 2442

534.6

3589 ACOUSTIC MEASURING INSTRUMENTS.
T.Schwirzer.
Z. InstrumKde, Vol. 67, No. 9, 223-31 (Sept., 1959). In German.

A survey of the most important acoustic measuring instruments commercially available in the German Federal Republic. The characteristic data are listed and critically compared. Suggestions are made for improving some of the instruments.

534.8

3590 ULTRASONIC MATTERSCOPE.
A.M.Voutsas.
J. Acoust. Soc. Amer., Vol. 32, No. 2, 282-3 (Feb., 1960).

Review of the work conducted since 1944 on the development of an instrument which, by means of ultrasonics, identifies a material, examines its microstructure and its homogeneity, detects impurities, and predicts its life before destruction. ("Matterscope" is a new word, coined by the author, to describe this instrument; hence the method "matterscopy").

534.8 : 539.2 : 535.33

INFLUENCE OF ACOUSTIC VIBRATIONS ON THE IMPURITY-ABSORPTION BANDS IN CRYSTALS. See Abstr. 2944

534.83

3591 SOUND ENERGY INTEGRATOR WITH AN ELECTROSTATIC SQUARING DEVICE.
J.P.A.Lochner and P.Meffert.
J. Acoust. Soc. Amer., Vol. 32, No. 2, 267-73 (Feb., 1960).

Investigations of the contribution of short-time delayed echoes to the intelligibility of speech have brought out the fact that reflections arriving within 95 msec after the direct sound in an auditorium have a positive contribution, and, reflections after this period, a negative contribution to the intelligibility of speech. The instrument described, developed for the analysis of reflection patterns in auditoria, incorporates an electrostatic squaring device and an electronic counter as registration unit. Sound energy can be integrated by means of this instrument over pre-determined short periods at any given interval after the direct sound.

534.85

3592 DETERMINATION OF THE RECORDING PERFORMANCE OF A TAPE FROM ITS MAGNETIC PROPERTIES.
E.D.Daniel and L.Levine.
J. Acoust. Soc. Amer., Vol. 32, No. 2, 258-67 (Feb., 1960).

The second of two papers dealing with the magnetic properties of recording tape. An analysis of h.f. biased recording is given based upon the anhysteretic properties of the tape as specified in Pt I (Abstr. 2222 of 1960). Calculations of performance are compared with the results of absolute measurements carried out on a conventional recording machine, and on large scale models. Satisfactory agreement is obtained when the theory is corrected to take into account a loss attributed largely to a dynamic form of demagnetization which takes place during recording. The corrected theory can be used to compare tape performance under a variety of operating conditions without reference to a particular test recorder. Attention is confined to recorded wavelengths which are large compared with coating thickness.

## OPTICS . PHOTOMETRY

535.24 : 77

3593 DIFFERENTIAL MICRODENSITOMETER.
A.H.Cook and R.G.Hitchins.
J. sci. Instrum., Vol. 36, No. 8, 337-41 (Aug., 1959).

The principle of a microdensitometer for the measurement of rate of change of photographic density as well as of density itself is discussed, and an experimental system is described. Examples are given of results that have been obtained in measurements of interferograms for the precise comparison of wavelengths of standard spectral lines.

535.24

### 3594 PRECISION MICROPHOTOMETER FOR USE WITH A VICKERS PROJECTION MICROSCOPE.

S.M.Makin and G.T.Rogers.

J. sci. Instrum., Vol. 36, No. 10, 428-32 (Oct., 1959).

A microphotometer has been designed to measure photographic density and density gradients in autoradiographs. The equipment is used with a Vickers projection microscope, being particularly useful in the quantitative study of autoradiographs from metallurgical specimens. Results can be obtained over a magnification range of 18.6 to 400 times. The photographic density is measured by balancing the output of two photomultipliers, one in the incident beam and one in the transmitted beam. Densities measured on this instrument were compared with the quoted values on a standardized density wedge and gave a standard deviation of 0.006.

535.24

### 3595 MICROSCOPE-SPECTROPHOTOMETERS.

L.S.Agroskin and N.V.Korolev.

Optika i Spektrosk., Vol. 6, No. 6, 832-3 (June, 1959). In Russian.

Describes two variants of a microscope-spectrophotometer. The first variant uses a "light probe" with which optical densities of small objects ( up to 1 $\mu^2$ in dimensions) can be measured at visible and ultraviolet wavelengths. The microscope part is used to observe the object. In the second variant it is possible to observe the object continuously during the process of measurement. The first and second variants can be also used simultaneously. The following types of work can be carried out with microscope-spectrophotometers: (1) recording of absorption spectra in the visible and ultraviolet regions of biological objects, dye films, solutions in microcells, organic and inorganic microcrystals, etc; (2) recording of fluorescence spectra of organic microcrystals and live water plants; (3) recording of ultraviolet absorption spectra of spots on paper chromatograms; (4) recording of reflection spectra of individual phases in metals and minerals. A.Tybulewicz

535.24

### 3596 ON THE NULL MODULATION METHOD FOR PHOTOMETRIC MEASUREMENTS. V.A.Kovalevsky.

Pribory i Tekh. Eksper., 1959, No. 3, 98-102 (May-June). In Russian.

Comparison of the intensities of two light beams is frequently made by modulating them and examining the amplified photocell signal. Conditions which the modulator should satisfy for maximum precision of measurement are set forth, and several modulators examined in this respect. The principle elements of the two most satisfactory modulators are a vibrating mirror and a vibrating prism respectively. D.J.Huntley

535.24

### 3597 ANGULAR VARIATION OF EXPOSURE FOR A LAMBERTIAN SOURCE. D.Levine.

J. Opt. Soc. Amer., Vol. 50, No. 3, 277-86 (March, 1960).

When the light passing through a lens is limited by a circular aperture of radius $\rho_a$, the variation of exposure follows the cosine-fourth law for a small Lambertian source at an infinite distance. For an object plane at a distance z from the lens, where $z \gg \rho_a$, the fractional deviation from the cosine-fourth law is $3(\rho_a/z)^2 \sin^2\psi_c$, where $\psi_c$ is the angle between the source and the optical axis measured at the centre of the aperture. Thus, if the object plane is more than $15\rho_a$ from the aperture, the cosine-fourth law deviates less than 1% from the exact expression when within $60^0$ of the optical axis. The cosine-fourth law always gives pessimistic results, so that in the absence of vignetting the illumination for a wide-aperture lens used for macrophotography may be much more uniform than indicated by this approximation. To reduce the exposure of a near object plane, the diaphragm opening can be reduced, which increases the angular variation of exposure; or the centre may be blocked so that an annular aperture is employed, thereby improving the uniformity of exposure. If the front lens element is the limiting aperture, the analysis applies without modification provided that the outer surface is plane or concave. Otherwise, the chord and radius of curvature of this surface determine a right circular cone with axis along the optical axis and vertex in front of the lens within which the exposure follows the same relations. For other locations of the object, or when the diaphragm is within the lens, distortion of the physical boundary of the aperture by lens aberrations prevents a general analysis. The results for the outer lens as the limiting element are pertinent, however, as other apertures can serve only to decrease the received energy further. The limitations on a general treatment of exposure apply even more severely to an analysis of vignetting. The gross characteristics of vignetting can be described to advantage, however, by means of a simple model consisting of circular apertures spaced along the optical axis. Thus it is shown that: (i) if only one additional aperture limits the light passing through the entrance pupil, then the smaller the diaphragm opening, the greater the angle from the optical axis before the onset of vignetting and the smaller the angle at which all light flux is blocked. (ii) If there are limiting apertures either side of the diaphragm, then the angle at which complete blocking of the light flux occurs is independent of the diaphragm radius, provided that the radius exceeds a certain minimum value.

535.24 : 539.1.07

### 3598 PHOTON COUNTERS FOR ACCURATE MEASUREMENTS OF ULTRAVIOLET RADIATION.

L.S.Shelkov, I.A.Prager and A.G.Kostin.

Pribory i Tekh. Eksper., 1959, No. 3, 50-6 (May-June). In Russian.

Describes experimental investigation of the characteristics of self-quenched photon counters using noble gas and an organic vapour and having various cathode materials. Most of the counters suffered from low photometric stability. The best results were obtained with counter having photo-cathode made of Cu-Mg or Cu-Be alloy; details of its construction and characteristics are given. The use of tungsten wire shield at the photo-cathode in this counter increased its photometric stability. 18 references. J.M.Zarzycki

## GEOMETRICAL AND INSTRUMENTAL OPTICS
## SPECTROSCOPY

*(Optical spectra and their analysis are included under the appropriate heading, e.g. Atoms, Molecules, Solid-State Physics, etc.)*

535.31

### 3599 LENS DESIGN: A NEW APPROACH.

O.N.Stavroudis.

J. Res. Nat. Bur. Stand., Vol. 63B, No. 1, 31-42 (July-Sept., 1959).

Describes a new method of defining the total aberrations of an optical system and its application to lens design. A system of partial differential equations defining optical image formation is written in the form of 4 by 4 matrices and is applied to the derivation of lens aberrations. It is shown that the form of the matrices facilitates the computation of these aberrations and that equations of condition on the lens parameters can be derived. The use of this method is illustrated through its application to a simple, well-known problem.

535.31

### 3600 PARABOLIC APPROXIMATION METHOD FOR AUTOMATIC LENS DESIGN. J.Meiron and G.Volinez.

J. Opt. Soc. Amer., Vol. 50, No. 3, 207-11 (March, 1960).

A method for automatic lens design is described, based upon the approximation of the curve describing the merit function plotted against a certain parameter, by a parabola. The minima of the parabolas of all design parameters are then chosen as the new values of the corrected system. When the order of the parabola is either known or approached sufficiently close, this method results in a fast convergence and avoids oscillations around the minimum point of the merit function. It thus has definite advantages over the least squares or the steepest descent methods, although the time required for one iteration is doubled in comparison with the corresponding time in the other methods. An actual correction of a Cooke triplet both by the least squares and by the new method is outlined.

535.31 : 77

### 3601 A NUMBER OF PROBLEMS OF THE WORKING PERFORMANCE OF OBJECTIVES. F.Hodam and E.Lau.

Optik, Vol. 16, No. 10-11, 586-94 (Oct.-Nov., 1959). In German.

The combination of a photographic objective and a light-sensitive material influences the production of the photographic image in different ways. The use of "blackening relief" in two-dimensional photometry furnishes information regarding these processes basic to the performance testing of photographic lenses. The effects of lens faults and the properties of the photographic emulsion on the picture are demonstrated by means of some examples.

535.31

### 3602 ON THE EFFECTS OF SMALL ERRORS IN THE ANGLES OF CORNER-CUBE REFLECTORS. K.N.Chandler.

J. Opt. Soc. Amer., Vol. 50, No. 3, 203-6 (March, 1960).

When a ray is reflected successively on three mirrors that are approximately mutually perpendicular, the ray is returned nearly parallel to the original direction. If the original and final directions are denoted by unit vectors q and −t, and if a, b, c are the normals to the three mirrors taken in order in a right-handed sense, then it is shown theoretically that

$$t = q + 2q^{\times} (+ \alpha a - \beta b + \gamma c),$$

to the first order in $\alpha$, $\beta$, $\gamma$, where these are the small angles by which the angles between the three mirrors exceed right angles. A geometrical construction to realize this formula is described. If the three reflecting faces are parts of the surface of a symmetrical solid tetrahedron, refraction at the fourth surface increases the angular deviation of the final ray from the incident ray by a factor of $\mu \cos r/\cos i$ for the component of the deviation in the plane defined by the incident ray and the normal, and by a factor of $\mu$ for the perpendicular component. (i is the angle of incidence, and $\mu \sin r = \sin i$). Finally, it is shown theoretically that this type of reflecting unit (with a curved refracting surface), when used at the rear of road vehicles, could have greater efficiency if one of the angles between the reflecting surfaces were 90.14° instead of 90°.

535.31

### 3603 GENERAL RELATION BETWEEN OBJECT AND IMAGE SPACE IN PLANE-MIRROR OPTICS. G.R.Rosendahl.

J. Opt. Soc. Amer., Vol. 50, No. 3, 287-9 (March, 1960).

Formulae are derived which permit the transfer of an object into any desired position behind a pair of plane mirrors. One mirror pair always suffices theoretically to solve this problem. The usefulness of the method is demonstrated with the help of the design of a highly efficient illumination system for a projector for opaque microrecords. It is then pointed out how to proceed if the first solution is not feasible.

535.31

### 3604 RONCHI TEST CHARTS FOR PARABOLIC MIRRORS. A.A.Sherwood.

J. Roy. Soc.New S.Wales, Vol. 93, Pt 1-2, 19-23 (Sept., 1959).

Deals with the preparation of a series of test charts giving the shape of the Ronchi shadow band patterns for testing parabolic mirrors for a wide range of aperture ratios. The method of application of the results to specific cases is discussed.

535.31

### 3605 THE SIEDEL EIKONAL INTRODUCED BY SCHWARZSCHILD AND THE STAEBLE—LIHOTZKY ISOPLANATIC CONDITION. H.Marz.

Optik, Vol. 16, No. 10-11, 610-16 (Oct.-Nov., 1959). In German.

The condition of isoplanatism is not the only possible condition for the coma being absent in the first approximation for small field and rigorously for any aperture. A slightly different condition results from Schwarzschild's differential relations derived from the existence of the eikonal introduced by him. The introduction of a "closed point-eikonal", slightly different from the one introduced by Schwarzschild (and which has the graphic interpretation of a closed optical path), yields still another condition for the absence of coma. Each time the strict definition of the absence of coma is slightly different; none of the three possibilities possesses a decisive advantage over the others. Each of the three, slightly different conditions is valid in the first approximation for small field — but rigorously for any aperture. Further useful applications of Schwarzschild's differential relations are given.

535.31

### 3606 THE EFFECT OF CURVATURE VARIATIONS OF AN ARBITRARY OPTICAL SYSTEM ON ITS FUNDAMENTAL PARAMETERS. J.Klebe.

Optik, Vol. 16, No. 12, 732-42 (Dec., 1959). In German.

Concerned with the influence of several arbitrary curvature errors of an optical system of k surfaces on its paraxial focus, lateral magnification, and its focal length. Starting with the laws of a Gaussian image, these investigations are carried out both exactly and in the first approximation, a successive method also being described. The final result can also be arrived at by specializing the general case where all the radii are variable. The results are discussed.

535.31

### 3607 OPTICAL SYSTEMS FOR FOCUSING INFRARED RADIATION ON TO A RECEIVER OF SMALL DIMENSIONS. I.V.Peisakhson.

Optika i Spektrosk., Vol. 6, No. 6, 831-2 (June, 1959). In Russian.

Two projection systems, each consisting of two spherical mirrors (one convex and one concave), are described. Spherical aberration can be corrected for in both systems when they are used at reductions of 4-10. Coma can be also corrected for in one of the systems and reduced in the other system. In both cases coma is lower than that produced by an elliptical mirror under the same conditions. Calculation shows that both spherical-mirror systems give a better image than an elliptical mirror used under the same conditions. A.Tybulewicz

535.31

### 3608 THE CONVERGENT THICK LENS. I. GRAPHICAL REPRESENTATION OF CHROMATIC VARIATION OF THE FOCAL LENGTH. A.Biot.

Ann. Soc. Sci. Bruxelles I, Vol. 73, No. 3, 345-53 (1959). In French.

Contours of constant longitudinal chromatic aberration are plotted, the coordinates being the first radius of curvature and the thickness, for given power and refractive index of the lens. The contours are hyperbolae. W.T.Welford

535.31

### 3609 THE CONVERGENT THICK LENS. II. ACHROMATISM OF THE AXIAL IMAGE POINT. A.Biot.

Ann. Soc. Sci. Bruxelles I, Vol. 73, No. 3, 354-62 (1959). In French.

Given the power, the first radius of curvature and the refractive index, an algebraic solution is obtained for the thickness and the second radius for axial achromatism; the conjugates are specified by the object and image distances from the principal foci. W.T.Welford

535.31

### 3610 EVALUATION OF LENS DISTORTION BY THE INVERSE NODAL SLIDE. F.E.Washer and W.R.Darling.

J. Res. Nat. Bur. Stand., Vol. 63C, No. 2, 105-12 (Oct.-Dec., 1959).

For previous work, see Abstr. 5488 (1959). The sources of error inherent in the method are investigated. Emphasis is given to the effect of asymmetric use of apertures. Measurements are reported on the same lens for which distortion values were measured by the direct nodal slide and photographic methods. A comparison of results obtained by the three different methods is given. It is concluded that accurate values of the distortion of a lens can be obtained by the inverse nodal slide method and that the precision of measurement is comparable to that of the two other methods mentioned when proper attention to sources of error is given.

535.31

### 3611 EVALUATION OF LENS DISTORTION BY THE MODIFIED GONIOMETRIC METHOD. F.E.Washer and W.R.Darling.

J. Res. Nat. Bur. Stand., Vol. 63C, No. 2, 113-20 (Oct.-Dec., 1959).

Presents the results of a study of the visual modified goniometric method which employs a viewing theodolite and accurate linear scale. Sources of error are investigated and discussed. Measurements are reported on the same lens that was used in the analysis of two visual and one photographic distortion measuring process. A comparison of results by the four different methods is given. It is concluded that accurate values of lens distortion can be obtained by the modified goniometric method provided care is taken to use centred apertures and to preserve known angular relationships between telescope pointings and successive locations.

535.32

### 3612 ELIMINATION OF OPTICAL DISCONTINUITY BETWEEN TWO IMMISCIBLE FLUIDS.

P.H.Scott, C.M.Sliepcevich and S.W.Churchill.

J. Opt. Soc. Amer., Vol. 50, No. 3, 300-1 (March, 1960).

The indices of refraction of heptane and of aqueous solutions of glycol were measured over a range of temperature. It is shown that the indices of this pair of fluids can be matched exactly and hence that the optical discontinuity at the interface of the two phases can be eliminated over a range of temperature by varying the composition of the solution. The utilization of this matched pair of fluids for light transmission measurements through dispersions is discussed.

535.32 : 537.56

### MEASUREMENT OF THE REFRACTIVE INDEX OF A PLASMA IN THE OPTICAL REGION. See Abstr. 3778

535.8

3613 AN OBJECTIVE WITH INCLINED OPTICAL AXIS FOR USE WITH THE POLARIZING MICROSCOPE. P.Bordet.
Bull Soc. Franc. Mineral. Crist., Vol. 82, No. 7-9, 234-8 (July-Sept., 1959). In French.

An attachment to a × 7 objective increases the magnification to 10.5 and permits viewing at 45° to the microscope axis in any azimuth. Applications to the determination of birefringence and of the angle between the optic axes of biaxial crystals are described.
W.T.Welford

535.8 : 548.7 : 539.2

3614 PRINCIPLES AND APPLICATIONS OF DIFFRACTION MICROSCOPY OVER THE WAVELENGTH RANGE FROM VISIBLE LIGHT TO GAMMA RAYS. R.Hosemann.
Naturwissenschaften, Vol. 46, No. 19, 542-52 (1959). In German.

Survey paper tracing the relationships between light microscopy according to the Abbe theory, X-ray diffraction techniques for the study of crystals and semi-crystals, and two-wavelength diffraction microscopy. 38 references. W.T.Welford

535.8

3615 RASTER ILLUMINATING DEVICES WITH CYLINDRICAL OPTICAL ELEMENTS.
A.K.Vinogradova and L.M.Ivantsov.
Optika i Spektrosk., Vol. 6, No. 6, 829-30 (June, 1959). In Russian.

Raster illuminators with cylindrical lenses can be used to avoid selective radiation losses due to motion of the source. In the absence of a raster the source of light fills a collimator objective along the vertical diameter only. A raster placed between the source and the spectrometer slit affects illumination of the slit and light distribution in the collimator, in the horizontal direction only. For the same illumination of the collimator objective in the horizontal direction, a raster condenser is less sensitive to horizontal and vertical displacements of the light source than a three-lens condenser. A.Tybulewicz

535.8 : 621.327.4

3616 HIGH INTENSITY, HIGH SPEED, MULTIFLASH APPARATUS. G.Dixon-Lewis and E.G.Jackson.
J. sci. Instrum., Vol. 36, No. 10, 417-18 (Oct., 1959).

An apparatus has been constructed to provide a number of high-intensity xenon flash discharges at time intervals from 0.1 to $2.5 \times 10^{-4}$ sec between flashes, each flash dissipating 300 J in approximately 180 msec. Two flash-head arrangements were used : in one, the tubes were mounted on a rotating disk thus giving a series of flashes from one fixed position, whilst the other consisted of a stationary bank of tubes, the location of the individual tubes determining the position of each flash.

535.8 : 621.383.2.032.35

3617 SOLID-STATE IMAGE INTENSIFIER UNDER DYNAMIC OPERATION. C.P.Hadley and R.W.Christensen.
R.C.A. Rev., Vol.20, No.4, 670-81 (Dec., 1959).

Describes the performance of photoconductor/electroluminescent-phosphor image intensifiers under dynamic conditions of operation. Both experimental data and theory are presented. The theory is based on some simplifying assumptions which allow easy analysis and permit an insight into the importance of the various parameters. The experimental data, however, conform the applicability of the analysis. Some suggestions concerning the possible improvement of intensifier performance are made.

535.33

3618 A STUDY OF PHOTOELECTRIC DETECTION IN A PULSING SYSTEM. ITS APPLICATION TO SPECTROMETRY OF THE RAMAN EFFECT. F.Valentin.
Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 11-12, 1239-90 (Nov.-Dec., 1959). In French.

Describes in detail the development of a high-sensitivity system for this application. The light source is a mercury vapour lamp employing mercury electrodes and pulsed by an ignitron circuit. The spectrometer detector is a photomultiplier tube which is mounted in a mechanically-driven cradle so as to sweep through the range 4300-5100 A. The photomultiplier feeds into an amplifier embodying integrating and gating networks for increasing the signal/noise ratio. The system is claimed to give an effective power gain of 500. The elimination of parasitic effects through the use of mercury electrodes with mercury vapour and the limited gain resulting from an increase of the discharge voltage from 10 to 100 kV are pointed out. H.G.M.Spratt

535.33

3619 PHOTOELECTRIC RECORDING OF RAMAN SPECTRA EXCITED WITH THE $\lambda = 5875$ A LINE FROM A HELIUM LAMP.
V.M.Pivovarov, L.A.Kir'yanova, Ya.S.Bobovich and G.N.Tarkhov.
Optika i Spektrosk., Vol. 7, No. 2, 258-9 (Aug., 1959). In Russian.

Describes a method of recording Raman spectra which gives good reproducibility and high resolution. A 3000 V, 0.2 A cold-cathode spiral helium lamp working under glow-discharge conditions at $p_{\text{He}} = 2$ mm Hg, was employed to excite the Raman spectrum (the 5875 A line was used). The spectra were obtained by means of a high-speed monochromator with a diffraction grating. A photomultiplier used as a receiver was able to record vibrational lines with frequencies up to 1600 $\text{cm}^{-1}$. The resolution of the instrument is illustrated on the 1004-1030 $\text{cm}^{-1}$ doublet of toluene and the 999-1017 $\text{cm}^{-1}$ doublet of iodoxybenzene. The first doublet was completely resolved and the second resolved to the extent of 80%.
A.Tybulewicz

535.33

3620 SOME APPLICATIONS OF A SPECTROMETER WITH HIGH DISPERSION IN MOLECULAR ANALYSIS USING RAMAN SPECTRA. V.A.Zubov, G.G.Petrash and M.M.Sushchinskii.
Optika i Spektrosk., Vol. 6, No. 6, 827-9 (June, 1959). In Russian.

A spectrometer for study of Raman spectra had a plane echelette grating with 600 lines/mm, ruled area 140 × 150 mm. The instrument was meant for use in the second order of the blue spectrum and had dispersion of 5 A/mm. A photomultiplier was used as a receiver. The spectrometer was employed to study line shapes and structure of bands consisting of closely spaced lines. Other possible applications are indicated. A.Tybulewicz

535.33

3621 TRANSMISSION FUNCTION FOR BANDS WITH DOPPLER–LORENTZ LINE SHAPES.
R.F.Hughes, H.Hurwitz, Jr and G.M.Roe.
J. Opt. Soc. Amer., Vol. 50, No. 3, 232-6 (March, 1960).

The mean transmission is calculated for spectral regions which have a random frequency distribution of absorption resonances with Doppler–Lorentz profiles. An effective constant strength band is defined which closely approximates the self-shielding of an arbitrary distribution of line strengths. By appropriately defining the half-width of the lines, the values of the shielding or self-absorption factor when plotted against the ratio of line strength to line width are identical for all line shapes in the region of small optical depth. The transmission calculations may be used in the interpretation of experiments to measure oscillator strengths and in the determination of the emissivity of high-temperature gases.

535.33

3622 A NEW METHOD OF INVESTIGATION OF EMISSION SPECTRA OF BODIES AT ROOM TEMPERATURE.
M.L.Veyngerov, L.M.Nechaeva, N.A.Pankratov and A.A.Sivkov.
Optika i Spektrosk., Vol. 4, No. 6, 797-9 (June, 1958). In Russian.
English summary: PB 141047T-11, obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

An apparatus claimed to be applicable to solids, liquids, and gases is briefly described. G.I.W.Llewelyn

535.33

3623 EFFECT OF THE CURRENT STRENGTH ON THE INTENSITY OF THE HYDROGEN SPECTRUM IN THE REGION 2500-1200 Å. I.I.Gromova and S.A.Kulikov.
Optika i Spektrosk., Vol. 7, No. 1, 130-1 (July, 1959). In Russian.

The intensity of emission by various hydrogen lamps was measured by means of a vacuum monochromator, with a photomultiplier as a receiver. These measurements were made on 350-400 W high-voltage water-cooled hydrogen lamps with and without windows of lithium fluoride. At wavelengths from 1216 to 2558 A only the intensity of emission at 1216 A was a linear function of the current (0.02-0.4 A); the remaining curves were sublinear. Intensity measurements were made also on a low-voltage hydrogen lamp, which was a 300 W point source with an oxide cathode (no cooling). At wavelengths from 1250 to 2558 A the intensities were sublinear functions of the current (2.6-5 A). A.Tybulewicz

535.33

3624 WAVELENGTH STANDARDS FROM A PAIR OF ANY DIFFERENTLY COLOURED TRANSPARENT MATERIALS. I.Sanchi and N.V.Parthasarathy.

Naturwissenschaften, Vol. 46, No. 9, 315 (1959).

Generalizing a previous suggestion by the authors (See Abstr. 3827 of 1958) the crossover point of the transmission curves of a pair of materials may be used to form a wavelength calibration point of a spectrophotometer. G.F.Lothian

535.33

### 3625 SELECTION OF THE SCANNING RATE, OPTIMUM TIME CONSTANT AND SLIT WIDTHS IN SPECTROMETRIC MEASUREMENTS.

G.G.Petrash.

Optika i Spektrosk., Vol. 6, No. 6, 792-7 (June, 1959). In Russian.

The author discusses values of the spectrometer parameters controlled by the experimenter, which give the smallest total root-mean-square error in recording of spectral characteristics, such as the line intensity or its half-width. The case of small systematic perturbations is dealt with and formulae are given, which are applicable in a wide range of spectral distributions, "apparatus" functions and properties of the recording system (the scanning rate, the time constant of the recording system or the slit width of the spectrometer). A.Tybulewicz

535.33

### 3626 THE FUNCTIONAL DESCRIPTION OF THE SPECTRAL LINE PROFILES IN THE COWAN–DIEKE AND BARTELS THEORIES.

N.G.Preobrazhenskii.

Optika i Spektrosk., Vol. 7, No. 2, 273-5 (Aug., 1959). In Russian.

Cowan and Dieke (Abstr. 3232 of 1948) and Bartels (Abstr. 4814 of 1950, 5240 of 1951, 6518 of 1950, 2717 of 1951 and 4332 of 1954) independently proposed theories which lead to relationships between the spectroscopic characteristics of optically non-uniform plasma of a gaseous discharge and the profiles of the spectral lines emitted by such a plasma. The present paper is a critical comparison of the expressions for the spectral line profiles given by the two theories. It was found that even in the special case when the line profile corresponding to an infinitely thin emitting layer does not depend on space coordinates, the Bartels theory is more complete and generally valid than the Cowan and Dieke theory. The reason for this lies in the greater generality of the Bartels solution of the variational problem; Cowan and Dieke over-restricted the function which describes the non-uniformity of the source.
A.Tybulewicz

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### 3627 DETERMINATION OF ABSORPTION OF ANALYTIC SPECTRAL LINES IN AN ARC AND IN A SPARK.

I.V.Podmoshenskii and V.M.Shelemina.

Optika i Spektrosk., Vol. 6, No. 6, 813-15 (June, 1959). In Russian.

Describes a method of measuring absorption using two identical sources. One source is an arc or a spark, in which the substance studied is placed. The other is a virtual source formed by focusing the light from the arc or the spark onto a concave mirror. Some of the light from the virtual source is absorbed by the arc or the spark and some of it passes on to a spectrometer slit. The method ensures that the two sources are exactly identical. A.Tybulewicz

535.33

### 3628 A LOW-VOLTAGE PULSE DISCHARGE IN VACUO USED FOR PRODUCTION OF SPECTRA.

F.Z.Pedos, N.S.Sventitskii and Z.I.Shlepkova.

Optika i Spektrosk., Vol. 6, No. 6, 815-17 (June, 1959). In Russian.

Describes several variants of a low-voltage pulse source working in vacuo. One variant had a porcelain spacer between the electrodes; this source produced the electrode spectra and the spectrum of the spacer. Two other sources had an auxiliary electrode, which avoided the inconvenience of the spacer. The discharges were produced by a bank of capacitors (5000-50 000 $\mu$F) in vacuo of $10^{-4}$-$10^{-5}$ torr. The discharge always started near the auxiliary electrode and then jumped over to the gap between the main electrodes. The best results were obtained using multiple pulses (100-200 discharges) of comparatively low intensity.
A.Tybulewicz

535.33

### 3629 IMPROVED LYMAN-CONTINUUM FLASH-SOURCE OF LARGE APERTURE.

W.R.S.Garton.

J. sci. Instrum., Vol. 36, No. 1, 11-16 (Jan., 1959).

Some of the difficulties attending use of earlier "Lyman flash-tubes", as background sources for vacuum u.v. absorption spectroscopy, have been mitigated or removed in a design employing a 1 cm bore constricting tube. The successful features of the device described have resulted from use of capacitors of high resonant frequency, the design of a discharge-tube of low inductance, and avoidance of a series spark-gap.

535.33

### 3630 CERTAIN POSSIBILITIES OF CORRECTING FOR THE VERTICAL ASTIGMATISM IN ASSEMBLIES ON ROWLAND'S CIRCLE. A VACUUM MONOCHROMATOR WITH A CONCAVE GRATING AND A TOROIDAL MIRROR.

Yu.P.Shchepetkin.

Optika i Spektrosk., Vol. 6, No. 6, 822-4 (June, 1959). In Russian.

The main disadvantage of a monochromator with a concave grating mounted together with the exit and entry slits on the circumference of Rowland's circle, is its vertical astigmatism. The paper describes a method of compensating for this astigmatism by means of a toroidal mirror placed in front of the monochromator entry slit. A.Tybulewicz

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### 3631 APPLICATION OF THE METHOD OF STORAGE IN THE PHOTOELECTRIC RECORDING OF THE TIME-RESOLVED SPECTRA OF LIGHT FLASHES.

B.A.Ermakov and A.A.Mak.

Pribory i Tekh. Eksper., 1959, No. 3, 94-7 (May-June). In Russian.

See Abstr 4320 (1954) and Abstr. 6277 B (1957); Philips tech. Rev., Vol. 19, No. 2, 50-8 (1957-58). A photoelectric apparatus is described for the recording of time-resolved spectra of light flashes, enabling a very high time and spectral resolution to be obtained. By applying pulse voltages instead of the conventional d.c. voltages to the electrodes of a photomultiplier tube, this tube can be made to operate as a light shutter capable of shutter times better than $1 \mu$sec. The spectrum is recorded automatically on the graph tape of a recording potentiometer. In the case of the Xe II line($\lambda$ = 2605 A) in spark discharge (frequency of flashes 15 c/s, time of establishment of the storage element 10 sec), the spectral resolution was 1.5 A, the time resolution $5 \times 10^{-8}$ sec. F.Lachman

535.33

### 3632 GRATING SPECTROPHOTOMETER FOR THE SCHUMANN ULTRA-VIOLET RANGE.

F.J.P.Clarke and W.R.S.Garton.

J. sci. Instrum., Vol. 36, No. 9, 403-9 (Sept., 1959).

Constructional and performance details are given of a photoelectric spectrophotometer erected for the measurement of the optical transmittances of small solid specimens, in the range above 900 A. The instrument incorporates a one-metre radius, 600 lines/mm concave grating, and scanning of the spectrum across the exit slit is performed by a linear movement of the centre of the Rowland Circle. The mechanical and electrical arrangements permit rapid measurements, quick exchange of specimen and the direct reading of transmittance on a 0-100 scale.

535.33

### 3633 THE HIGH-SPEED DFS-12 DIFFRACTION GRATING SPECTROMETER.

S.L.Berkovich, M.V.Gofren, M.V.Lobachev, T.K.Fal'k and D.I.Sharonov.

Optika i Spektrosk., Vol. 6, No. 6, 824-6 (June, 1959). In Russian.

This spectrometer, using diffraction gratings and photoelectric recording makes it possible to record Raman spectra of transparent liquids and diffusely scattering substances, such as turbid solutions, powders and glasses, in the region 3600-6400 A. Optically the spectrometer is a double-mirror monochromator with two diffraction gratings. To correct for aberrations, non-symmetric incidence on gratings was employed and parabolic mirrors used. The gratings had 600 lines/mm (a ruled area of $140 \times 150$ mm) and were used in the second order. The instrument can resolve a weak line at a distance of 11 cm$^{-1}$ from a strong line. A.Tybulewicz

535.33 : 539.18

### 3634 A PHOTOELECTRIC SPECTROMETER WITH A FABRY–PEROT INTERFEROMETER.

N.I.Kaliteevskii, G.M.Malyshev and M.P.Chaika.

Optika i Spektrosk., Vol. 6, No. 6, 820-2 (June, 1959). In Russian.

High resolving power of the instrument was ensured by a Fabry–Perot interferometer with dielectric ($TiO_2$ and $SiO_2$) reflecting coatings. The interferometer was placed in a hermetically sealed chamber, in which the pressure could be varied from several mm Hg to one atmosphere. The apparatus was employed to record the hyperfine structure of lines of certain isotopes of lutetium, gadolinium and holmium. A hollow-cathode discharge tube was used as the light source. A.Tybulewicz

535.33 : 77
BLACKENING OF PHOTOGRAPHED SPECTRUM LINES.
See Abstr. 2263

# PHYSICAL OPTICS

*(Luminescence is included under Solid-State Physics, Liquid State, or Gaseous State)*

535.39
3635 REDUCTION OF REFLECTION OF METALLIC COATINGS. I.N.Shklyarevskii and A.A.Avdeenko.
Optika i Spektrosk., Vol. 6, No. 5, 678-84 (May, 1959). In Russian.

Reduction of reflection at the glass-metal boundary in the Fabry–Perot interferometer plates, with the reflectivity at the air-metal boundary unchanged, would improve transmission of the plates and consequently increase their speed, contrast and resolving power. Such a reduction can be achieved by evaporating a thin film (100-150A) of silver on a glass plate heated to 300-400°C and then depositing the main aluminium layer. Transmission of semi-transparent aluminium coatings on glass pre-treated in this way is increased by a factor of 2 to 4 in the wavelength region 600-1100 mμ. Transmission of semi-transparent coatings of silver can be improved by a factor of 1.5 to 2.8 when these coatings are deposited on glass plates previously covered with 100-150 A silver films (deposited at 300-400°C) on top of which very thin aluminium layers were evaporated.
A.Tybulewicz

535.41
3636 MEASUREMENT OF LOW ABSORPTION IN SEMI-REFLECTING FILMS. A.R.Cownie.
J. Opt. Soc. Amer., Vol. 50, No. 3, 289-94 (March, 1960).

A method is described of measuring the low absorption of a semireflecting film by making use of the effect of the absorption on the interference fringes obtained with the film. The method is to measure the conditions under which an etalon illuminated normally in both directions gives a uniform field of view. From a study of the sources of error in the method it is concluded that the accuracy of measurements made on multilayer dielectric films is three times that which can be expected from straightforward measurements with the same apparatus of R and T. A further threefold improvement is available if a satisfactory physical method of exploring the field of view is used in place of visual inspection.

535.41
3637 PHASE DISPERSION IN MULTILAYER FILMS. C.F.Bruce and P.E.Ciddor.
J. Opt. Soc. Amer., Vol. 50, No. 3, 295-9 (March, 1960).

The phase change with wavelength was measured for some multilayer dielectric films at specific wavelengths and at low orders of interference (20 to 40). Some results for silver films are included for comparison. The method employed multiple-beam Fizeau fringes superimposed on channelled spectra, providing a simple means of obtaining the orders, both integral and fractional. The order of magnitude of the phase dispersion with the multilayer films made it necessary to compare theoretically computed values with the experimental values in order to determine the integral order uniquely. These theoretical values were calculated by matrix and Smith chart methods.

535.41 : 539.23
3638 AGEING EFFECT IN EVAPORATED FILMS OF ZINC SULPHIDE. Lee Sang Soo.
Proc. Phys. Soc., Vol. 74, Pt 5, 641-3 (Nov., 1959).

Changes in the phase retardation of light transmitted by approximately λ/4 ZnS films of order 1° were found over periods of a few days.
W.T.Welford

535.41
3639 INTERFERENCE LIGHT-FILTERS MADE OF MULTI-LAYER DIELECTRICS. T.N.Krȳlova.
Optika i Spektrosk., Vol. 6, No. 6, 784-7 (June, 1959). In Russian.

Describes properties of interference light-filters consisting of alternate layers of titanium dioxide and silicon dioxide prepared by hydrolysis of ethyl esters of orthotitanic and orthosilicic acids. Stable transmission filters were obtained for work in the 380-850 mμ region. They passed up to 80% of incident light through a narrow transmission band (half-width of 6-12 mμ).
A.Tybulewicz

535.41
3640 INTERFERENCE FILTERS FOR THE ULTRAVIOLET REGION OF SPECTRUM. R.S.Sokolova and T.N.Krȳlova.
Optika i Spektrosk., Vol. 6, No. 6, 788-91 (June, 1959). In Russian.

Describes reflection filters made up of alternate layers of thorium dioxide and silicon dioxide, which are transparent in the region 220-400 mμ. Using these filters, selective reflection from a quartz surface can be increased up to 95%. Stable interference transmission filters were also produced from these layers. The latter filters pass up to 80% through their transmission bands (half-widths of 6-14 mμ) situated in the 250-400 mμ region.
A.Tybulewicz

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3641 PHOTOELECTRIC DOUBLE-SLIT INTERFEROMETER FOR INVESTIGATION OF TRANSPARENT THIN SOLID FILMS. Lee Sang Soo.
J. sci. Instrum., Vol. 36, No. 9, 385-7 (Sept., 1959).

The interferometer is of the Rayleigh two-slit type. A glass plate partly covered by the film covers one slit and the resulting fringe is a measure of the phase retardation due to the film. The shift is determined photoelectrically using a homodyne detection system to locate the fringe minimum. A sensitivity of λ/7000 is obtained.

535.41
3642 STREAK INTERFEROMETRY. F.D.Bennett, D.D.Shear and H.S.Burden.
J. Opt. Soc. Amer., Vol. 50, No. 3, 212-16 (March, 1960).

A modification of the Mach–Zehnder interferometer is described which permits streak interferometry of transient axisymmetric flows. Examples are shown of interferograms taken of flows produced by exploding fine metallic wires. Prominent features of the interferograms include (1) clearly defined shock waves; (2) a narrow, transparent, flow region behind the strong shock where fringes may be seen; (3) an opaque region presumed to be caused by the dispersed metal, and (4) luminous regions associated with the second shock wave and electronic excitation of the material near the axis of symmetry.

535.41
3643 APPLICATION OF MULTIPLE BEAM INTERFERENCE TO THE MEASUREMENT OF LONG END STANDARDS. J.B.Saunders.
J. Opt. Soc. Amer., Vol. 50, No. 2, 183-4 (Feb., 1960).

A technique is described in which white light fringes of superposition are secured by combining a Fabry–Perot etalon with a Michelson interferomenter. Fringes are obtainable for values of the Michelson path which are integral multiples of the Fabry–Perot path. The system can be adapted to the measurement of long end-standards.
S.Tolansky

535.41
3644 INTERFERENCE FRINGES WITH MERCURY-198 AND A PATH DIFFERENCE OF 2000 mm. I.C.Gardner and K.F.Nefflen.
J. Opt. Soc. Amer., Vol. 50, No. 2, 184 (Feb., 1960).

A Connes type Fabry-Perot interferometer with spherical mirrors separated by 100 mm was constructed and was used as a monochromator for the Hg green line. It should have given a line width of 0.003 $\text{cm}^{-1}$, with which fringes should have been found over a path difference of 3 metres; in fact fringes were easily visible at 2 metres path difference, the longest obtainable on the available Michelson interferometer.
W.T.Welford

535.41
3645 INTERFEROMETER BASED ON FOUR DIFFRACTION GRATINGS. F.J.Weinberg and N.B.Wood.
J. sci. Instrum., Vol. 36, No. 5, 227-30 (May, 1959)

An interferometer based on diffraction gratings, used over their whole area, and designed to overcome some of the disadvantages of the four-mirror Mach–Zehnder arrangement is described. Its theoretical and practical assessment leads to the conclusion that, in comparison with the latter, it is remarkably inexpensive and insensitive to misalinement, though wasteful of light and subject to certain residual optical imperfections.

535.41
3646 METHOD OF MEASURING DISPLACEMENT USING OPTICAL GRATINGS. D.L.A.Barber and M.P.Atkinson.
J. sci. Instrum., Vol. 36, No. 12, 501-4 (Dec., 1959).

A method using three diffraction or shadow gratings for accurate near measurement. Comparison between the gratings produces two lternating signals, and the change of phase difference between the signals is proportional to the distance measured.

535.42

### 3647 DIFFRACTION GRATINGS FOR SEPARATION OF SPECTRAL ORDERS.

.N.Rassudova and F.M.Gerasimov.
Optika i Spektrosk., Vol. 6, No. 6, 826-7 (June, 1959). In Russian.

The authors prepared special reflection gratings which could be used to separate spectra of various orders produced by other diffraction gratings with any number of lines per mm. These reflection gratings (separator-gratings) had 50 or 100 lines mm. Their line profile was step-like with working surfaces inclined at ° to the original surface in order to concentrate light in the first order. A.Tybulewicz

535.42

### 3648 THE THREE-DIMENSIONAL INTENSITY DISTRIBUTION NEAR THE FOCUS OF WAVES DIFFRACTED BY SLIT AND RECTANGULAR APERTURES. B.J.Thompson.

Proc. Phys. Soc., Vol. 73, Pt 6, 905-11 (June, 1959).

The intensity near the focus of a converging wave diffracted by a rectangular aperture is investigated both theoretically and experimentally. The theoretical work is based on an extension of the classical analysis of Lommel. The experimental work is carried out using an optical diffractometer, and the positions of the axial minima on either side of the geometrical focus are measured. The results of theory and experiment are compared in various receiving planes near the geometrical focal plane.

535.43

### 3649 POSITIONS OF EXTREMA IN THE FUNCTIONS DESCRIBING SCATTERING OF LIGHT BY SPHERICAL PARTICLES. Yu.V.Mal'tsev.

Optika i Spektrosk., Vol. 7, No. 1, 124-6 (July, 1959). In Russian.

Ratio of the light (energy) flux scattered by a spherical particle in all directions to the flux incident on the area equal to the cross-section of this particle is given by a scattering function. This function has principal maxima and minima, on which secondary maxima and minima are superimposed. The principal extrema positions are, it is suggested, given by

$$\alpha_k = 1 + 4k/(mm^* - 1)$$

where k is a positive integer; $m = n(1 - ix)$ is the complex refractive index, n is the real refractive index and x is the absorption index of the particle; $m^*$ is the complex conjugate of m. The maxima are obtained by using odd values of k and the minima correspond to even values of k. The author shows that the above formula is in good agreement with published work on scattering by both transparent and absorbing particles. In the latter case, however, the formula is valid only for small values of x, but it can be used to calculate the position of the first principal maximum for all values of x.

A.Tybulewicz

535.43 : 541.18

### 3650 EFFECT OF ADSORBED WATER ON THE OPTICAL TRANSMISSION PROPERTIES OF ISOTROPIC POWDERS. P.Debye and L.K.H.van Beek.

J. chem. Phys., Vol. 31, No. 6, 1595-7 (Dec., 1959).

An isotropic powder immersed in a liquid of the same refractive index in monochromatic light will scatter part of the light when an adsorbed layer of different index is present on its surface. A theory is developed that relates the apparent absorption coefficient to the thickness of the adsorbed layer. Data on water adsorption on glass powders show a good agreement between theory and experiment.

535.51 : 539.2

### 3651 OPTICS OF ABSORBING MAGNETIC CRYSTALS. I. POLARIZATION OF UNIFORM PLANE WAVES.

L.M.Tomil'chik and F.I.Fedorov.
Optika i Spektrosk., Vol. 5, No. 4, 462-8 (1958). In Russian.

Deals with polarization of plane uniform electromagnetic waves propagated in a non-active medium with an arbitrary anisotropy of the dielectric, magnetic and conducting properties. The discussion is given in a general invariant form. A.Tybulewicz

535.51 : 539.2

### 3652 OPTICS OF ABSORBING MAGNETIC CRYSTALS. II. FIELD VECTORS FOR PLANE WAVES. REFRACTIVE INDICES AND OPTICAL AXES.

L.M.Tomil'chik and F.I.Fedorov.
Optika i Spektrosk., Vol. 5, No. 5, 601-5 (1958). In Russian.

The difference between the equations for plane electromagnetic waves in absorbing magnetic crystals and the corresponding equations for transparent magnetic crystals can be reduced to replacement of a real permittivity tensor $\epsilon$ by a complex tensor $\epsilon'$. Following Fedorov's earlier work (1956) it is concluded that optical properties of absorbing magnetic crystals should be determined primarily by a tensor $\gamma' = (\epsilon')^{-1}\mu$. The $\gamma'$ tensor is in general complex and asymmetric, but it may be made symmetrical by using a real symmetric permeability tensor $\mu$. Using a canonical dyad representation for the tensor $\gamma'$ the authors obtained general invariant expressions which give complex refractive indices and polarization of plane uniform monochromatic waves, as well as the directions of the optical axes. A.Tybulewicz

535.51 : 535.8

### 3653 A SPECIAL CASE OF THE SUPERPOSITION OF CRYSTAL PLATES BETWEEN CROSSED POLARS AND ITS BEARING ON THE MICROSCOPY OF CELLULOSIC FIBRES.

N.H.Hartshorne.
Nature (London), Vol. 184, 179-81 (July 18, 1959).

If two crystal $\lambda/2$ plates are superposed with their principal directions forming an angle $\theta$, between crossed polarizers, the extinction is independent of their orientation with respect to the polarizers and depends only on $\theta$. An application to the microscopy of thick fibres is pointed out. W.T.Welford

535.52

### 3654 FRESNEL'S FORMULAE FOR INCIDENCE OF AN ORDINARY WAVE ON THE TWINNING PLANE OF A TRANSPARENT UNIAXIAL CRYSTAL. G.B.Rais.

Optika i Spektrosk., Vol. 6, No. 3, 384-8 (March, 1959). In Russian.

Derives ordinary and extraordinary-wave reflectivity and refractivity of the plane of separation between twins in a transparent uniaxial crystal when an ordinary wave falls on this plane. Discusses variation of reflectivity and refractivity with the angle of incidence.

A.Tybulewicz

535.55

### 3655 PHOTOELECTRIC MEASUREMENTS ON FLOW BIREFRINGENCE. H.Wayland.

C.R. Acad. Sci. (Paris), Vol. 249, No. 14, 1228-30 (Oct. 5, 1959). In French.

If linearly polarized light transverses a liquid subjected to a flow gradient the emergent light is elliptically polarized. The elliptical vibration may be restored to a linear vibration by a suitably oriented quarter-wave plate but the vibration direction is rotated away from its original direction by an amount dependent on the magnitude of the birefringence introduced by the liquid. Thus the measurement of flow birefringence can be reduced to a measurement of rotation. In this paper the method described by Gillham (Abstr. 3182 of 1957) and Wenking (Abstr. 6808 of 1959) for the measurement of small rotations in polarimetry is considered applicable and its adaptation to flow birefringence measurements discussed. In this method the initial direction of vibration of the linearly polarized light is made to oscillate about a mean position and it is stated that a satisfactory signal to noise ratio is obtainable when the amplitude of the oscillation is about 35°. H.G.Jerrard

535.55

### 3656 NEW APPARATUS FOR MEASURING FLOW BIREFRINGENCE. H.Janeschitz-Kriegl.

Rev. sci. Instrum., Vol. 31, No. 2, 119-23 (Feb., 1960).

A description is given of the design of an apparatus for measuring flow birefringence; the pertinent theory has been published previously (Abstr. 8546 of 1957). In this apparatus glass cylinders are used, instead of the usual metal cylinders. A slow convection stream which moves parallel to the cylinder axis, removes part of the frictional heat generated in the annular gap. In that way a rising temperature distribution throughout the cross-section of the gap, as was described by Björnstahl (Abstr. 893 of 1944), is prevented. This temperature distribution, as is well known, causes the divergence of the light beam and, consequently, reflection at the walls of the cylinders. However, in the apparatus described in this paper, no reflections occur and, as a consequence, the appearance of a parasitic double refraction is avoided. Some results of measurements on solutions of cellulose nitrate in cyclohexanone are communicated.

## COLORIMETRY . PHOTOGRAPHY

535.6

3657 RECORDING COLORIMETER FOR DETERMINING REFLECTION CURVES OF COLOURED BODIES SUCH AS FLOWER PETALS. H.Driescher and W.Hiller.
Exper. Tech. der Phys., Vol. 7, No. 4, 182-7 (1959). In German.

Descriptions of colours of flowers by reference to a colour atlas are subjective and physical measurement is to be preferred, but the method used must be as sensitive as the eye to small colour differences. In the instrument described, the leaf and a standard white surface of adjustable luminance are illuminated alternately by light from a monochromator. Two photocells, matched as far as possible for colour responses, receive the light from the two surfaces and lack of balance causes a neutral wedge to be moved across the white surface until balance is obtained. The same movement is imparted to a pen recording on a cylinder whose travel is linked with movement of a prism in the monochromator. Some spectral reflection curves obtained with the apparatus are reproduced and compared with those given by a Hardy spectrophotometer.
J.W.T.Walsh

535.6

3658 STANDARDS OF REFLECTANCE. W.Budde.
J. Opt. Soc. Amer., Vol. 50, No. 3, 217-20 (March, 1960).

The reflectances of a number of different barium sulphate substances were measured. The measurements show a correlation between the reflectance and chemical impurities as well as their grain sizes. In view of the problem of developing better working white standards, the importance of these results is discussed with respect to the magnesium oxide white standard, as well as the perfect diffuser which the C.I.E. recently recommended for ultimate adoption as the reference standard.

535.65

3659 ILLUMINANT FOR THE COLORIMETRY OF FLUORESCENT MATERIALS. W.Harrison.
J. sci. Instrum., Vol. 36, No. 5, 234-6 (May, 1959).

The colorimetry of specimens containing fluorescent whitening agents (optical bleaches) requires an illuminant with adequate ultraviolet content to at least 3600 A. Single sources based on the filament lamp have, generally, a low ultraviolet content. The use of two sources, one equivalent to Illuminant C provided by a filament lamp screened with an O.B. 8 filter, and the second the same lamp screened with an O.X. 1 or modified O.X. 1 ultraviolet filter is suggested as giving a satisfactory approximation to the daylight spectral distribution, both in the visible and in the ultraviolet regions.

77

3660 SYSTEMS ANALYSIS OF THE PHOTOGRAPHIC PROCESS. I. A THREE-STAGE MODEL. D.H.Kelly.
J. Opt. Soc. Amer., Vol. 50, No. 3, 269-76 (March, 1960).

A nonlinear isotropic model is proposed to account for the microimaging behaviour of the photographic process, without violating well-known properties of its large-area tone scale. Image growth and other "adjacency" effects are predicted. Each stage of the model is described in detail, and methods of determining the output image for any given input image are discussed. A typical step-function response is calculated by way of example.

77

3661 ILLUMINATION, CONTRAST, SPECTRUM, AND COLOR CONDITIONS IN AN "AVERAGE" OUTDOOR SCENE AS FUNCTIONS OF GROUND REFLECTANCE, OBJECT ORIENTATION, AND VIEWING DIRECTION. M.R.Nagel.
Optik, Vol. 16, No. 12, 697-724 (Dec., 1959). In German.

An attempt is made to define the concept of an "average" outdoor scene for application in the development of photographic equipment and material. The average outdoor scene consists primarily of a white sphere on a neutral grey or white ground under a clear sky at a sun altitude of 40 degrees. The distribution of illumination, reflection spectra, and colour on the surface of such an object is investigated. The contrast (or exposure range) and the spectral uniformity of the illumination on the object are determined as a function of both the ground reflectance and the direction from which the object is photographed or viewed.

77 : 612.8 : 621.397

LAND'S EXPERIMENTS IN TWO-COMPONENT COLOUR PHOTOGRAPHY AND COLOUR VISION. See Abstr. 3374

77

3662 FOURIER ANALYSIS OF THE ADJACENCY EFFECT IN PHOTOGRAPHIC EMULSION. K.Sayanagi.
K.Sayanagi.
J. Opt. Soc. Amer., Vol. 50, No.2, 185 (Feb., 1960).

The author shows how the adjacency effect can be treated by Fourier analysis for a simple sinusoidal test pattern. The result illustrates some of the effects that have been obtained experimentally in determination of the response function of photographic emulsions.
R.W.Fish

77 : 548.5

3663 FORMATION AND GROWTH OF SILVER NUCLEI IN SILVER HALIDE MICRO-CRYSTALS.
E. Klein and R. Matejec.
Z. Elektrochem., Vol. 63, No. 8, 883-91 (1959). In German.

Irradiation of silver halide grains in an electric field indicated that interstitial Ag ions were present, and that these took part in the formation of latent image nuclei and photolytic Ag. An electron microscope was used to determine the number of latent image nuclei in a grain after chemical development. The number of nuclei at first increases with increasing pulsed light intensity and then decreases, the nuclei becoming larger and directly observable. Large photolytic Ag particles can also initiate the development reaction. On irradiation with equal amounts of light (constant intensity - time product), the number of nuclei formed increases with intensity.
J.Franks

77 : 535.31

PHOTOGRAPHIC IMAGE FORMATION. VARIOUS EFFECTS OF A LENS—LIGHT-SENSITIVE MATERIAL SYSTEM.
See Abstr. 3601

77

3664 TESTS ON THE LENS OF THE GALILEO—SANTONI PHOTOGRAMMETRIC CAMERA, MODEL VI.
C.Trombetti.
Atti Fond Ronchi, Vol. 14, No. 6, 585-98 (Nov.-Dec., 1959).
In Italian.

Tests of resolving power and distortion have been carried out on the wide-angle (90°) 6 inch lens used in the model VI camera. The camera gives 50 lines/mm on axis, 20 lines/mm at 45° for a high contrast test object and Kodak Super XX film. The distortion has a maximum value of 0.012 mm at 35°. A brief account of the methods of making the tests is given.
R.W.Fish

77

3665 MONITOR-SYNCHRONIZER FOR ROTATING MIRROR CAMERAS. W.B.Farrand and G.E.Gagnon.
Rev. sci. Instrum., Vol. 30, No. 10, 939-41 (Oct., 1959).

The device shows when the angular velocity of the mirror has attained a chosen value. A signal from a transducer near the rotating mirror is compared with the standard signal. A Lissajous Figure is displayed on a c.r.t. when synchronization is achieved. When the camera shutter is opened, the next pulse from the transducer initiates the explosion with the mirror in the correct angular position.
E.R.Wooding

77 : 535.24

DIFFERENTIAL MICRODENSITOMETER.
See Abstr. 3593

# HEAT . RADIATION

536.2

### 3666 THE COOLING OF A HOT WIRE IN SUBSONIC FLOW
V.Bartošek.

Czech. J. Phys., Vol. 8, No. 6, 716-25 (1958). In German.

The equilibrium temperature $T_r$ attained by a heated W wire 10 to 20 $\mu$ thick) in an air stream is measured. The apparatus is escribed. The results show that $T_r = T_0(1 - \eta\lambda)$ where $\lambda$ is the Mach number, $\eta$ depends on the wire diameter and $T_0$ corresponds o the unheated wire. For the range $\lambda = 0.25$ to $0.53$ the relation $Nu = \beta\sqrt{Re} + \gamma$ where $\beta$ and $\gamma$ are constants is valid. S.Weintroub

536.2

### 3667 AN IMPLICIT, NUMERICAL METHOD FOR SOLVING THE TWO-DIMENSIONAL HEAT EQUATION.
G.A.Baker, Jr and T.A.Oliphant.

Quart. appl. Math., Vol. 17, No. 4, 361-73 (Jan., 1960).

In the linear case, the full two-dimensional set of implicit equations is solved exactly. This solution is made possible by choosing a difference scheme for which the equations are factorable into two one-dimensional sets. This factorability is basic to the method. This method is extended to non-linear equations and non-rectangular regions by the use of an iterative scheme to solve the implicit equations obtained. This scheme provides second-order convergence, and in the cases tested only a very few iterations per time step were required. The method is proved to be unconditionally stable both in the linear and non-linear cases.

536.2

### 3668 AN IMPLICIT, NUMERICAL METHOD FOR SOLVING THE n-DIMENSIONAL HEAT EQUATION.
G.A.Baker, Jr.

Quart. appl. Math., Vol. 17, No. 4, 440-3 (Jan., 1960).

An extension of the work of the previous abstract to the n-dimensional, linear problem with arbitrary spacing between the mesh points. An implicit scheme is given which can be solved exactly, and it is proved that it is unconditionally stable. The generalization to the non-linear case may be treated in precisely the same way as in the 2-dimensional case.

536.22

### 3669 TRANSMISSION OF HEAT OR MATTER IN THE TURBULENT REGIME. E.Rukenshteïn.
Rev. de Physique (Bucarest), Vol. 4, No. 2, 245-53 (1959). In Russian.

In the first part of the paper heat exchange between a solid and a liquid is investigated assuming that the flow is turbulent. In order to make the deductions manageable, simplified assumptions are introduced concerning the temperature of the liquid in contact with the solid surface. An expression for the heat transfer coefficient is obtained. In the second part,mass transfer is investigated on the assumption that on the surface of the solid a chemical reaction is in progress. R.Eisenschitz

536.23

### 3670 HEAT TRANSFER COEFFICIENTS BETWEEN FLUID JETS AND NORMAL SURFACES. BEHAVIOUR OF LAMINAR IMPACTED JETS. J.M.F.Vickers.
Industr. engng Chem., Vol. 51, No. 8, 967-72 (Aug., 1959).

Heat transferred from a hot plane surface by a normally directed jet of air under different conditions was estimated by means of thermocouple measurements in the plane surface. Interpretation is complicated by unexpected features in the air flow after impact, which is not parallel to the surface. J.G.Oldroyd

536.24 : 532.7

HEAT-TRANSFER AND HIGH-TEMPERATURE PROPERTIES OF LIQUID ALKALI METALS. See Abstr. 3526

536.25

### 3671 HEAT TRANSPORT BY CONVECTION.
Y.Nakagawa.

Phys. of Fluids, Vol. 3, No. 1, 82-6 (Jan.-Feb., 1960).

The character of heat transport by cellular convection, which arises beyond the marginal state of stability in a layer of fluid bound between two constant temperature surfaces is examined. It is shown that a simple equation characterizes the heat transport in the neighbourhood of the marginal state of stability when the convection is steady, and its cellular pattern of motion is represented by the solutions of the linear theory. The results of the study include all three cases of boundary conditions, namely, when the bounding surfaces of the layer are both free, and both rigid, or one is free and the other is rigid.

536.25 : 538.3

### 3672 HEAT TRANSPORT BY CONVECTION IN PRESENCE OF AN IMPRESSED MAGNETIC FIELD. Y.Nakagawa.
Phys. of Fluids, Vol. 3, No. 1, 87-93 (Jan.-Feb., 1960).

The effect of an impressed magnetic field on heat transport by convection, which arises from instability in a layer of an electrically conducting fluid, bounded between two constant temperature surfaces, is examined. It is shown that such a field reduces the amount of heat transported by convection, and that when the strength of the magnetic field is increased, such reduction becomes proportional to $(\pi^2 Q)^{-1}$, where $Q = \sigma\mu^2 \cos^2 vH^2 d^2/\rho\nu$, d is the depth of the layer, $\rho$ the density, H the strength of magnetic field, v the inclination of the direction of H to the vertical, and $\sigma$, $\mu$ and $\nu$ are the coefficients of electrical conductivity, magnetic permeability, and kinematic viscosity, respectively, for all types of the boundary conditions. It is also shown that in the neighbourhood of the marginal state of stability, a simple formula characterizes the heat transport by convection.

536.3 : 621.317.794

### 3673 HIGH-SPEED BOLOMETER.
H.E.Stubbs and R.G.Phillips.

Rev. sci. Instrum., Vol. 31, No. 2, 115-18 (Feb., 1960).

Intended for measuring the radiation from nuclear fireballs. The bolometer is made by successive depositions of an insulating layer and a gold sensing element upon a copper block which serves as a heat sink. An analysis of the bolometer's performance indicates that it has a response time of approximately 50 $\mu$sec.

536.3

### 3674 INFLUENCE OF BACKGROUND HEAT EMISSION ON READINGS OF RADIATION RECEIVERS.
B.I.Stepanov and A.S.Rubanov.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 3, 517-20 (Sept. 21, 1959). In Russian.

An integrating paper, giving detailed examination of methods of accounting for background heat emission and its influence on spectroscopic readings of radiation receivers. J.K.Skwirzynski

536.41

### 3675 APPARATUS FOR COMBINED THERMAL ANALYSIS AND DILATOMETRY. J.H.Pearce and P.G.Mardon.
J. sci. Instrum., Vol. 36, No. 11, 457-60 (Nov., 1959).

An apparatus is described for carrying out simultaneous differential thermal analysis and dilatometry on small metallic samples at temperatures up to 1200° C in a vacuum. Automatic temperature control and recording are important features of the method, and a discussion of the chief sources of error is given.

536.42

### 3676 DESCRIPTION OF A THERMISTOR CRYOMETER, AND CRYOMETRY BY THE METHOD OF COMPLETION OF MELTING. P.Huyskens, P.Claes and J.L.Gailliez.
Ann. Soc. Sci. Bruxelles I, Vol. 73, No. 3, 383-9 (1959). In French.

A thermistor cryometer was designed to study the time variation of the temperatures of the solid and liquid phases of a substance at its melting point. On the basis of heterogeneous reaction kinetics, an exponential relation between the temperature of the liquid phase and time is predicted, provided that the total area of the crystals in the solid phase remains constant. The theoretical relation has been investigated experimentally, using pure benzene, and is only obeyed during the initial stages of melting: as time progresses, the total surface area of the crystals decreases and the relation no longer holds. C.H.B.Mee

536.42

### 3677 MECHANISM OF EVAPORATION OF Be IN A HIGH VACUUM.
V.M.Amonenko, L.N.Ryabchikov, G.F.Tikhinskii and V.A.Finkel'.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 5, 977-8 (Oct. 11, 1959). In Russian.

Mass-spectrometric investigation of the evaporation of distilled high-purity Be disclosed that: (1) Be evaporates mostly as $Be_2$ from the solid phase (below 1300° C), and (2) as Be from the liquid phase (above 1300° C); (3) at temperatures above 1400° C the reaction $Be + BeO = Be_2O$ takes place, whose product is stable at normal conditions (the existence of $Be_2O$ was confirmed by X-ray photographs). $Be_2O$ is more volatile than BeO and is one of the sources of contamination of Be with O when the metal is distilled from beryllia crucibles. F.Lachman

536.42

### 3678 TORSION-EFFUSION APPARATUS FOR THE STUDY OF VAPOUR PRESSURES OF ALLOYS.

J.N.Pratt and A.T.Aldred.

J. sci. Instrum., Vol. 36, No. 11, 465-8 (Nov., 1959).

A simple apparatus for the direct measurement of vapour pressures of metals by the torsional deflection of an effusion cell is described. Results are given showing its use for the study of solid and liquid alloys. Its suitability for this purpose is discussed.

536.46

### 3679 DIFFUSION COEFFICIENTS IN FLAMES AND DETONATIONS WITH CONSTANT ENTHALPY.

J.O.Hirschfelder.

Phys. of Fluids, Vol. 3, No. 1, 109-12 (Jan.-Feb., 1960).

It is found that the entropy per gram of mixture remains constant in a flame or a one-dimensional chemically reacting gaseous flow system if all the binary diffusion coefficients are equal to each other and $D_{ij} = \lambda/(\bar{C}_p mn)$, where $\bar{C}_p$ is the specific heat at constant pressure per gram of the mixture, m is the average molecular weight of the mixture, and n is the number of moles per gram. This value for each of the binary diffusion coefficients corresponds to setting each of the Lewis numbers equal to unity. For detonations, or systems having large kinetic energy, the enthalpy (per gram) including kinetic energy remains constant if, in addition to the diffusion coefficients having this special value, the Prandtl number is equal to $\frac{3}{4}$. It is clear that the assumption of constant enthalpy should not be applied to hydrogen—bromine or hydrogen—oxygen flames where some coefficients of diffusion are very large and others very small. The constant enthalpy assumption is applied to unimolecular decomposition flames supported by the reaction $A \rightarrow sB'$. It is found that, to a rough approximation, the flame velocity varies as the 1/12th power of s.

536.46

### 3680 STATISTICAL STUDY OF ACCELERATING FLAMES.

R.A.Stern, A.J.Laderman and A.K.Oppenheim.

Phys. of Fluids, Vol. 3, No. 1, 113-20 (Jan.-Feb., 1960).

Study of velocity fluctuations observed by means of ionization probes during the development of detonation reveals its significance as an indicator of physical characteristics of the flame. The scatter in time of arrival (the reciprocal of the velocity) was found normally distributed at an 85% probability level. The means and standard deviation were determined within 5% and 20%, respectively, at a confidence level of 90%. The intensity of scatter is interpreted consequently as indicative of the combustion front fluctuation that can be considered to delineate the "effective flame thickness". It is found then that, as the flame accelerates, its effective thickness first increases, reaching a maximum in the vicinity of velocity overshoot, and then decreases, attaining finally a minimum, constant value when the steady detonation wave is established. An interesting bimodal distribution of scatter for the $2H_2-O_2$ mixture has been observed, indicating a possible existence of two alternative, independent modes for the development of the process.

536.46

### 3681 THEORY OF FLAME PROPAGATION IN SOLID NITROGEN AT LOW TEMPERATURES.

S.G.Reed and C.M.Herzfeld.

J. chem. Phys., Vol. 32, No. 1, 1-2 (Jan., 1960).

A theory for a flame in a solid whose speed is controlled by diffusion of radicals and heat is applied to slowly propagating flashes observed in solid nitrogen deposited at 4°K from a microwave discharge. Reasonable agreement is obtained with observed speeds.

536.46

### 3682 TEMPERATURE-REGULATED IGNITION SOURCE.

J.Preston and L.E.Ashman.

Rev. sci. Instrum., Vol. 31, No. 1, 53-8 (Jan., 1960).

The temperature controller described here is capable of heating a fine wire (of the order of a few mils in diameter) to some temperature between 700°C and the melting temperature, and holding the temperature constant to within a few degrees. The detector is a photomultiplier that monitors radiation from the centre of the wire; changes in radiation result in compensating changes in the current. The controller responds within a millisecond to sudden changes in the environment of the wire. This rapid response is useful for detecting the onset of ignition in reactive gases and perhaps for measuring the thermal properties of nonreactive gases.

536.5

### 3683 MEASUREMENT OF THE TEMPERATURE OF A RUNNING THREAD-LINE. M.F.Culpin and D.M.Jones.

J. sci. Instrum., Vol. 36, No. 1, 28-9 (Jan., 1959).

Instruments are described which may be used to measure the temperature of a running textile thread-line. They entail the elimination of the difference in temperature between the thread-line and an independently heated thermocouple.

536.5 : 621.317.39

### 3684 TECHNIQUES OF CATHODE TEMPERATURE MEASUREMENTS AS APPLIED TO COMMERCIAL CATHODE-RAY TUBES. P.P.Coppola.

Rev. sci. Instrum., Vol. 31, No. 2, 137-43 (Feb., 1960).

Thermocouple, optical pyrometer, and retarding potential techniques for the measurement of cathode temperatures have been investigated to determine their relative merits, limitations, and corrections. The thermocouple method is accurate and reliable provided necessary lead loss corrections are made. Application of this method to commercial tubes is limited by the expense involved. The optical pyrometer method is questionable when applied to an oxide-cathode coating due to considerable spread in spectral emissivity data; however, the method is reliable when applied to the cathode base nickel. The retarding potential method shows good correlation to the other methods and is directly applicable to commercial tubes with no modifications required. However, limitations are imposed by a number of factors, notably the stability of cathode emission and leakage current levels.

536.51

### 3685 REALISATION AND UTILISATION OF THE THERMOMETRIC FIXED POINTS. Y.Doucet and J.P.Ravoux.

J. Phys. Radium, Vol. 18, No. 3, 41A-44A (March, 1957). In French.

A simple construction of triple point cells for the calibration of thermometric instruments instead of ice and steam points is described. The triple point of water, 0.01 deg C allows a precision of one millidegree much more easily than the ice-point. The triple point of benzoic acid gives a temperature accurate to within 1°C. This precision is difficult to reach with the steam point. The triple point of diphenyl oxide, which is in the vicinity of room temperature has also been used.

536.53

### 3686 APPLICATION OF INDIUM RESISTANCE THERMOMETRY. J.W.Stewart.

Rev. sci. Instrum., Vol. 30, No. 10, 949 (Oct., 1959).

Gives particulars of the use of indium wire for the range 4°-300°K. E.G.Knowles

536.58

### 3687 SEMI-AUTOMATIC CONTROL SYSTEM FOR PRODUCING CONSTANT COOLING RATES.

L.W.Phipps.

J. sci. Instrum., Vol. 36, No. 11, 449-52 (Nov., 1959).

This control system was designed and is best suited for cooling, at a constant rate, the metal sample block of a differential thermal analysis apparatus used for studying supercooling, melting and solidification phenomena in organic materials. An automatically-controlled flow of liquid refrigerant, passing through a simple heat exchanger, is used to cool the primary liquid circulating continuously in the coil system of the block. The apparatus is also suitable for uniform cooling of a small water or oil bath. For either application, controlled cooling rates of up to about 2°C/min are attainable. Using refrigerated water, control is possible from 95 down to about 10°C depending on the rate, but the range could be extended to lower temperatures by the choice of suitable liquid coolants.

536.6

### 3688 CALORIMETER WITH AUTOMATIC CONTROL.

G.Bullock.

J. sci. Instrum., Vol. 36, No. 1, 20-2 (Jan., 1959).

The temperature differences between the specimen and its surrounding reference shield in a Smith's calorimeter, modified o operate in a vacuum, is held constant by automatically adjusting the power input to the furnace. Fine adjustment is achieved by a variable reactance in the power supply. The reactance control current is obtained from a single valve d.c. amplifier, the control signal of which is the output voltage of a Wheatstone bridge network containing two photocells. Departures from the desired temperature difference cause a light spot reflected by a galvanometer to move from one to the other photocell, and so adjust the furnace power input and restore the original conditions. Specific heat-temperature curves smooth to within ±0.5% and reproducible within 3% have been obtained between 50-250° C.

536.6

3689 COMPACT CALORIMETER FOR MEASURING THE OVERALL THERMAL EFFICIENCY OF FREESTANDING FIRES AND STOVES FOR ROOM WARMING. M.W.Thring.

J. sci. Instrum., Vol. 36, No. 12, 488-91 (Dec., 1959).

The heat output by convection and radiation of a modern solid fuel room heater is best measured by a calorimeter absorbing all the heat. By using a comparatively small water cooled box enclosing the heater good absolute accuracy and rapid response can be obtained and the heat output should not differ by more than 1% from that in an average large room. Such a box can be simply constructed from insulated "tube-in-strip" and the air flow in and the rate of loss of weight of fuel in the heater can be continuously measured.

## THERMODYNAMICS

536.7

3690 THE CONCEPTS OF CLASSICAL THERMODYNAMICS. H.A.Buchdahl.

Amer. J. Phys., Vol. 28, No. 3, 196-201 (March, 1960).

This paper, which is itself in the nature of an abstract, discusses how one can gain an understanding of the basic concepts of classical (phenomenological) thermodynamics, using virtually no mathematics at all, and without the introduction of the usual artifices such as abstract engines, cycles, perfect gases, and so on.

536.7

3691 THERMODYNAMICS, STATIONARY STATES, AND STEADY-RATE PROCESSES. I. INTRODUCTION AND MIGRATIONAL EQUILIBRIUM IN ISOTHERMAL AND MONOTHERMAL FIELDS. R.J.Tykodi.

J. chem. Phys., Vol. 31, No. 6, 1506-10 (Dec., 1959).

A method of obtaining thermodynamic relationships for systems in stationary states, for steady-flow processes, and for steady-rate processes in general is outlined. The method is shown to be applicable to equilibrium systems, and a monothermal concentration field is treated briefly.

536.7

3692 THERMODYNAMICS, STATIONARY STATES, AND STEADY-RATE PROCESSES. II. MIGRATIONAL EQUILIBRIUM IN THERMAL FIELDS. R.J.Tykodi and T.A.Erikson.

J. chem. Phys., Vol. 30, No. 6, 1510-16 (Dec., 1959).

The thermodynamic method outlined in Pt I for treating stationary states and steady-rate processes is applied to a discussion of nonisothermal systems. Thermomolecular pressure, thermo-osmotic and thermal diffusion effects are treated in detail.

536.7 : 539.2 : 537.32

3693 THERMODYNAMICS, STATIONARY STATES, AND STEADY-RATE PROCESSES. III. THE THERMOCOUPLE REVISITED: R.J.Tykodi.

J. chem. Phys., Vol. 31, No. 6, 1517-21 (Dec., 1959).

The thermodynamic properties of the thermocouple are treated according to the principles developed in Pts I and II. The steps in the derivation of the Thomson relations seem to imply that a homogeneous thermoelectric effect does not exist.

536.7

3694 THERMODYNAMICS, STATIONARY STATES, AND STEADY-RATE PROCESSES. IV. STEADY MONOTHERMAL RATE PROCESSES. R.J.Tykodi and T.A.Erikson.

J. chem. Phys., Vol. 31, No. 6, 1521-5 (Dec., 1959).

The procedure outlined in Pt. I is applied to such steady monothermal rate processes as forced vaporization, diffusion, Poiseuille flow, and chemical reaction. In the case of forced vaporization, numerical values of a coefficient defined in terms of entropy production are computed from the data of Alty(1931) pertaining to the vaporization of water and of carbon tetrachloride.

536.7

3695 THE FUEL CELL AND THE CARNOT CYCLE. H.A.Liebhafsky.

J. Electrochem. Soc., Vol. 106, No.12, 1068-71 (Dec., 1959).

To provide a basis for considering the combination of nuclear reactor (or other heat source) and fuel cell, the well-known fact that the fuel cell escapes the Carnot-cycle limitation is reviewed briefly. Then it is shown that the combination cannot escape this limitation and, in some cases, can only approach the Carnot-cyle efficiency.

## LOW-TEMPERATURE PHYSICS

536.48 : 530.16

PHASE TRANSITIONS IN A BOSE GAS. See Abstr. 3462

536.48

3696 FILM BOILING OF LIQUEFIED GASES ESPECIALLY OF LIQUID HELIUM I. T.Frederking and P.Grassmann.

Bull. Inst. Internat. Froid, Annexe 1958-1, 317-22.

Experimental results for the heat transfer coefficient as a function of the temperature excess of heated Pt wires of various diameters between 5 and 50 $\mu$ over the boiling temperature of liquid He I and $N_2$ at atmospheric pressure are presented. The results can be expressed by $Nu = 2.5\ (Gr\ Pr)^{0.11}$ where $10^{-7} < (Gr\ Pr) < 10^{-1}$

S.Weintroub

536.48

3697 He II FILM PROFILE AND RELATIVE IMPORTANCE OF HEIGHT AND SURFACE PRESSURE.

O.T.Anderson, D.H.Liebenberg and J.R.Dillinger.

Phys. Rev., Vol. 117, No. 1, 39-42 (Jan. 1, 1960).

The thickness d of the He II film at 1.40° K versus height h to 40 cm was measured by an optical method. Results agree better with an expression of the form $d = kh^{-1/3}$ than with $d = kh^{-1/2}$ or $h = (a/d)^3 + (b/d)^2$. Evidence was obtained suggesting that the contour of the film cannot be accounted for by considering it to be an adsorbed film subjected to a varying pressure. The pressure would decrease with height due to gravitational effects in a vertical gas column.

536.48

3698 SOME THERMAL PROPERTIES OF LIQUID HELIUM THREE. L.Goldstein.

Phys. Rev., Vol. 117, No. 2, 375-81 (Jan. 15, 1960).

The various anomalies exhibited by the thermal properties of liquid He$^3$ originate with its nuclear spin system according to the statistical thermodynamic formalism elaborated for the latter. This result of general character is verified directly through a quantitative evaluation of the volume expansion coefficient of the saturated liquid. The theory also yields the explanation of the observed pressure dependence of the temperature locus of its volume anomalies near saturation at moderate pressures. The quantitative extension of the theory into the regions of the compressed liquid and the solid will have to await the forthcoming of precise measurements of several thermal properties in these phases of He$^3$.

536.48

3699 ON THE THEORY OF LIQUID AND SOLID He$^3$. L.Goldstein.

Ann. Phys. (New York), Vol. 8, No. 3, 390-434 (Nov., 1959).

An attempt is made to develop quantitatively several features of the theory of the nuclear spin system in liquid and solid He$^3$, elaborated previously. The effect of the application of external pressure on the spin system is thus described in a more rigorous way than heretofore. The attempt to correlate the various experimentally determined thermal properties of the compressed liquid from the standpoint of the theory of the spin system leads one to recognize the need of new and precise nuclear paramagnetic susceptibility measurements in order to verify various predictions of the theory. One of these concerns the strictly asymptotic temperature approach of the nuclear paramagnetic susceptibility of the liquid, or the solid, toward its limiting ideal Langevin–Brillouin limit. This feature of the susceptibility appears to be necessary for an explanation of the locus of the vanishing expansion coefficients located, at already moderate pressures, at relatively high temperatures, $T > \sim 1.0^\circ$K. On assuming the absence of nuclear magnetic anomalies, the spin system of the solid is expected to render this phase also anomalous in its thermal properties, up to relatively high temperatures and pressures. Within certain relatively mild limitations, it is shown that solid He$^3$ may exhibit two possible types of thermal excitation of its normal degrees of freedom. One of these corresponds to excitations which appear to be particle like, as those of the liquid all over its phase diagram. They impose at low temperatures negative latent heats in the solid–liquid phase change, through the dominance of the entropy decrease of the nuclear spin system in this transformation. In the other case, phonon types of thermal excitation appear to be allowed, provided the solid–liquid phase separation line has a positive though small temperature slope at low temperatures.

536.48

### 3700 THE ABSORPTION OF SOUND IN DILUTE SOLUTIONS OF HELIUM-3 IN LIQUID HELIUM II.

G.O.Harding and J.Wilks.

Phil. Mag. (Eighth Ser.), Vol. 3, 1469-71 (Dec., 1958).

The absorption of 14.7 Mc/s sound in liquid helium II has been studied and it has been found that, below 1.8$^\circ$K, the absorption is considerably reduced by the presence of small concentrations of He$^3$ (0.32%, 1.6% and 5.2% molar having been studied). This is attributed to a change in the second viscosity brought about by an increase of equilibrium-producing collisions due to the presence of the He$^3$. L.Mackinnon

536.48

### 3701 HEAT TRANSPORT IN LIQUID He$^3$.

D.M.Lee and H.A.Fairbank.

Phys. Rev., Vol. 116, No. 6, 1359-64 (Dec. 15, 1959).

The thermally conductivity of liquid He$^3$ at a pressure of $\frac{2}{3}$ atm was determined experimentally and found to increase slowly from $7 \times 10^{-5}$ watt/cm $^\circ$K at 0.24$^\circ$K to $16 \times 10^{-5}$ watt/cm$^\circ$K at 2.7 $^\circ$K with no evidence of superfluiduty. Several models of liquid He$^3$ based on Fermi–Dirac statistics predict a 1/T dependence for the thermal conductivity of He$^3$ at the lowest temperatures, but no such behaviour was observed down to 0.24$^\circ$K. A study of the convective heat transport in the liquid indicated that the coefficient of thermal expansion becomes negative below about 0.5$^\circ$K. A thermal boundary resistance across a copper–liquid He$^3$ interface was found which is similar in magnitude and temperature dependence to that found for a copper–superfluid He$^4$ boundary.

536.48

### 3702 HIGH-CURRENT SUPERCONDUCTIVITY.

R.H.Parmenter.

Phys. Rev., Vol. 116, No. 6, 1390-9 (Dec. 15, 1959).

The Bardeen, Cooper, and Schrieffer theory of superconductivity (Abstr. 1708 of 1958) is extended to the case of high current densities by explicitly including in the phonon-induced electron–electron attraction the modification of the phonon spectrum in a moving coordinate system. This modification results from the Doppler effect. In materials having cross-sectional dimensions of the order of the penetration depth, it is shown that at current densities of the order of $10^9$ amp/cm$^2$ the superconducting state is stable relative to the normal state, this holding both in superconducting metals and in metals ordinarily not considered superconducting at all. For this high-current state, it appears possible to obtain superconducting transition temperatures as high as room temperature. Means for achieving such an effect experimentally are discussed.

536.48

### 3703 BARDEEN–COOPER–SCHRIEFFER THEORY OF SUPERCONDUCTIVITY IN THE CASE OF OVERLAPPING BANDS.

H.Suhl, B.T.Matthias and L.R.Walker.

Phys. Rev. Letters, Vol. 3, No. 12, 552-4 (Dec. 15, 1959).

The B.C.S. theory is extended to overlapping s and d bands with densities of states $N_s$ and $N_d$, and interaction energies $V_{ss}$, $V_{dd}$ and $V_{sd}$. In general the energy gaps are different for the two bands, unless $N_s = N_d$, but both gaps fall to zero at the same transition temperature, unless $V_{sd} = 0$. R.G.Chambers

536.48

### 3704 THEORY OF DIRTY SUPERCONDUCTORS.

P.W.Anderson.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 26-30 (Sept., 1959).

A B.C.S. type of theory is sketched for very dirty superconductors, where elastic scattering from physical and chemical impurities is large compared with the energy gap. This theory is based on pairing each one-electron state with its exact time reverse a generalization of the k up, −k down pairing of the B.C.S. theory which is independent of such scattering. Such a theory has many qualitative and a few quantitative points of agreement with experiment, in particular with specific-heat data, energy-gap measurements, and transition-temperature versus impurity curves. Other types of pairing which have been suggested are not compatible with the existence of dirty superconductors.

536.48

### 3705 SEMI-EMPIRICAL CALCULATION OF THE TRANSITIO TEMPERATURE OF SUPERCONDUCTORS AND OF TH EFFECT OF PRESSURE ON THE TRANSITION.

P.Morel.

J. Phys. Chem. Solids, Vol. 10, No. 4, 277-85 (Aug., 1959). In French

A method is developed to take into account the contribution of the umklapp process to the electron–phonon interaction in polyvalent metals. This method is used to compute — from first principles — the high-temperature resistivity of non-transition metals as well as the transition temperature $T_c$ of non-transition superconductivity along the lines of the B.C.S. theory of superconductivity. The effect of pressure on $T_c$ is also computed and its dependence upon the band structure is stressed.

536.48

### 3706 THE EFFECT OF NEUTRON IRRADIATION ON THE SUPERCONDUCTING PROPERTIES OF RHENIUM.

J.Doulat, B.B.Goodman, M.Renard and L.Weil.

C. R. Acad. Sci. (Paris), Vol. 249, No. 20, 2017-19 (Nov. 16, 1959).

The effect of neutron bombardment on the superconducting properties of rhenium has been studied by observations on the $H_c$–T curves, on values of $T_c$ and on frozen-in moments. It is concluded that the observed effects correspond more to the formatio of lattice defects than to impurities introduced by nuclear transformation. L.Mackinnon

## ELECTRICITY
## ELECTRICAL MEASUREMENTS

537.7

### 3707 A FOUR-ELECTRODE PROBE WITH MERCURY CONTACTS FOR DETERMINING THE RESISTIVITY OF SILICON [PLATES].

H.Frank.

Czech. J. Phys., Vol. 9, No. 4, 524-8 (1959). In Russian.

A description is given of an instrument whose measuring probe has mercury contacts which have linear characteristics and a low resistance (after previous formation by a condenser discharge). The instrument can be used to make resistivity measurements on any semiconductor.

537.7 : 538

### 3708 A MECHANICAL MODULATOR FOR MAGNETIC FIELDS AND THE POSSIBILITY OF THE MEASUREMENT OF SMALL HALL MOBILITIES.

V.N.Bogomolov.

Fiz. tverdogo Tela, Vol. 1, No. 5, 829-31 (May, 1959). In Russian.

Four methods of measuring Hall voltage are considered. Two of these require a variable magnetic field and the possibility of modulating a static magnetic field, by mechanically moving the pole tips of a magnet relative to the specimen, is discussed. The experimental arrangement for such a determination is examined and the minimum observable values of Hall coefficient and Hall mobility are given. K.N.R.Taylor

537.7 : 621.317.715

### 3709 GALVANOMETER FEEDBACK SYSTEMS.

J.A.Sirs.

J. sci. Instrum.,Vol. 36, No. 5, 223-7 (May, 1959).

The principles of applying feedback to a galvanometer, after optical and electronic amplification, are discussed. In particular, the galvanometer performance is examined when proportional, differential, compound and selective feedback systems are used. The latter method is compared with mechanical and series-capacitor tuning of the galvanometer response.

537.7 : 621.317.755

### 3710 SAMPLING OSCILLOSCOPE FOR MILLIMICROSECOND PULSES AT A 30 Mc REPETITION RATE.

A.S.Farber.

Rev. sci. Instrum., Vol. 31, No. 1, 15-17 (Jan., 1960).

A sampling oscilloscope with a rise time of $3 \times 10^{-10}$ sec is described. It may be used with carrier or noncarrier periodic signals having a high fixed repetition rate. A novel coincidence circuit employed in the device for displaying the envelope of 1 mμsec bursts of 10 kMc/s energy is also presented.

537.7 : 621.317.727.2

### 3711 ELECTROLYTIC POTENTIOMETER AS A GENERAL PURPOSE PHYSIOLOGICAL TRANSDUCER.

W.G.Whittlestone.

J. sci. Instrum., Vol. 36, No. 1, 8-11 (Jan., 1959).

The use of the electrolytic potentiometer as a transducer for physiological measurements is described. Two suitable types of amplifier circuit are given; one in which the output from the electrolytic cell drives a cathode follower as a stable power amplifier, and another in which a second electrolytic cell is coupled to a recording milliammeter, and the latter used as a phase sensitive servo-motor to balance changes in the measuring cell. A transistor amplifier circuit suitable for portable equipment is given as part of the second application.

537.7 : 621.375.222

### 3712 HIGH-GAIN D.C. AMPLIFIER FOR BIOLOGICAL PURPOSES. S.V.Hill.

J. sci. Instrum., Vol. 36, No. 7, 297-300 (July, 1959).

A "starved operation" d.c. amplifier is described, having a drift of less than 100 μV in 30 min, grid current less than $10^{-11}$ A and a noise level referred to the input of 15 μV with 10 MΩ grid resistors. Circuits are also described for using the amplifier with commercial cathode-ray and pen oscillographs.

## ELECTROSTATICS . DIELECTRICS

*(The study of solids through their dielectric properties is included under Solid-State Physics; similarly for Liquid State and Gaseous State)*

537.2

### 3713 IMPROVED EQUIPMENT FOR THE MEASUREMENT OF INTERFACIAL POTENTIALS.

C.D.Kinloch and A.I.McMullen.

J. sci. Instrum., Vol. 36, No.8, 347-9 (Aug., 1959).

A modified vibrating-electrode apparatus designed for the reliable measurement of air-water and oil-water adsorption potentials is described. The equipment is capable, under the best conditions, of measuring potential differences of 0.2 mV at the air-water surface and of 0.5 mV at the oil-water interface. The surface potentials of small quantities (0.1 ml) of aqueous solutions may be measured rapidly to a lesser degree of accuracy.

537.2

### 3714 INFLUENCE OF X-RAYS ON THE ELECTRIFICATION OF NaCl CRYSTALS. A.Szaynok.

J. appl. Phys., Vol.31, No.1, 211-12 (Jan., 1960).

Pulverized crystals were made to fall through an electric field between two vertical plates and their tracks were observed using stroboscopic illumination. Unirradiated crystals gave a symmetrical distribution of number versus charge per unit area with the maximum centred at zero charge density. The irradiated crystals, with an F-centre concentration of $10^{18}$/cm$^{-3}$, gave tracks with discontinuities caused by photoelectric emission. The distribution calculated from the initial part of the track has its maximum in the positive charge region, while that using the final portion of the track has the maximum displaced further towards positive electrification. It is suggested that irradiation increases the mean charge of the dust cloud by increasing the number of lattice defects. A.E.Kay

537.2

### 3715 THE CAUSE OF CAPACITANCE CHANGES IN A CONDENSER CONTAINING A CRYSTAL PHOSPHOR WHICH IS BEING EXCITED. M.Borisov.

Izv. Bulg. Akad. Nauk, Vol. 6, 51-67 (1956: publ. 1957). In Bulgarian, with summary (1 p) in English.

It is shown that the capacitance changes occurring in condensers having a thin layer of a powdered phosphor (e.g. CdS monocrystals) in them can be entirely accounted for by conductivity inhomogeneities in the phosphor produced by absorption of light. In certain condensers with such crystals the capacitance changes are anomalously large, probably due to barrier layers at the contacts. A.Tybulewicz

537.2

### 3716 CHARGE PENETRATION INTO A CONDUCTOR IN EQUILIBRIUM. R.Fürth and E.Morris.

Proc. Phys. Soc., Vol. 73, Pt 6, 869-72 (June, 1959).

Statistical mechanics is used to show that the electric charge on a conductor in equilibrium is not restricted to its surface but penetrates into the interior in the form of a space charge density, the effective penetration depth being of the order of a few atomic distances. Similarly, the electric potential in a charged conductor is not strictly constant but varies in space which results in a small but finite potential difference between the interior and the surface layers.

537.2 : 539.2 : 621.317.39

### 3717 AN ABSOLUTE METHOD OF MEASUREMENT OF DIELECTRIC PROPERTIES OF A SOLID USING A π-SHAPED RESONATOR. O.V.Karpova.

Fiz. tverdogo Tela, Vol. 1, No. 2, 246-55 (Feb., 1959). In Russian.

Describes an absolute method of measuring permittivity ($\epsilon$) and tan $\delta$ of a cylindrical sample in a $\pi$-shaped cavity. The resonance curve with the sample in the resonator yields the resonance wavelength $\lambda$, and then a calibration curve, $\epsilon = f(\lambda)$, is used to find $\epsilon$. The error in determination of permittivity values up to $\epsilon = 30$ is less than 1% and it is independent of the sample dimensions. The value of tan $\delta$ can be found from the Q-factor of the resonator with the sample in it. The values of $\epsilon$ and tan $\delta$ of five substances (polystyrene, ebonite, sulphur, sodium chloride and titanium dioxide), measured at $\lambda = 15$-43 cm, were generally in agreement with the published data. A.Tybulewicz

537.2 : 539.2

### 3718 THE USE OF SLOW SURFACE WAVES FOR THE MEASUREMENT OF THE DIELECTRIC PERMITTIVITY OF SUBSTANCES AT ULTRA HIGH FREQUENCIES. I.

V.P.Shchestopalov and K.P.Yatsuk.

Zh. tekh. Fiz., Vol. 29, No. 7, 819-30 (July, 1959). In Russian. English translation in: Soviet Physics—Technical Physics (New York), Vol. 4, No. 7, 740-50 (Jan., 1960).

A method of measuring dielectric permittivity, $\epsilon'$, by comparing the wavelength of ultra high frequency waves guided by a wire spiral, empty or with its interior completely or partially filled with dielectric. The theory is given for both cases and simple formulae obtained for justifiable approximations whereby $\epsilon'$ can be obtained from the two wavelengths with and without dielectric. Minor effects arising from the periodicity of the spiral serve to improve the accuracy. An experimental investigation is described using a short-circuited spiral. Results for $\epsilon'$ are given in the free space wavelength range 18 to 30 cm for ebonite ($\epsilon' \cong 2.7$) and porcelain ($\epsilon' \cong 4.5$). $\epsilon'$ appears to be substantially independent of wavelength in both cases. An extension of the method to liquids is promised.
J.G.Powles

537.2 : 621.317.73

### 3719 SIMPLE APPARATUS FOR MEASURING DIELECTRIC CONSTANTS AND LOSSES FROM 10 c/s TO 50 kc/s.

J.C.S.Richards.

J. sci. Instrum., Vol. 36, No. 1, 22-3 (Jan., 1959).

A simple bridge circuit is used with a battery-operated detector. No coupling transformers or Wagner earth adjustments are required. The dielectric constant is measured by a substitution method, and the losses in terms of the equivalent parallel resistance.

537.2

### 3720 SOLUTION OF THE PROBLEM OF THERMAL BREAKDOWN OF DIELECTRICS WITH ASYMMETRICAL BOUNDARY CONDITIONS. S.N.Koikov and A.N.Tsikin.

Fiz. tverdogo Tela, Vol. 1, No. 5, 789-97 (May, 1959). In Russian.

The problem is solved for a plane-parallel dielectric between electrodes kept at different temperatures. Equations are derived for the thermal breakdown voltage and for the temperature distribution in a dielectric stressed at a given voltage. Z.Krasucki

537.2

### 3721 DIELECTRIC BREAKDOWN OF POROUS CERAMICS. R.Gerson and T.C.Marshall.

J. appl. Phys., Vol. 30, No. 11, 1650-3 (Nov., 1959).

A statistical approach is used to determine the effect of porosity in ceramic materials on their dielectric breakdown strength. The calculated drop in dielectric strength is in good agreement with the experimental data for lead zirconate titanate ceramics. The theory shows that the measured dielectric strength in porous materials is a function of the porosity, the void size, and of the dimensions of the test sample.

537.2

### 3722 DIELECTRIC PROPERTIES OF DISPERSE SYSTEMS: SOLID DIELECTRICS–CONDUCTORS. K.Leibler.

J. Chim. phys., Vol. 56, No. 7, 677-82 (July, 1959). In French.

The variation of the dielectric constant with the amount of conducting powder in a dielectric medium is found to depend on the particle size of the powder and on the dielectric and conducting materials used. The experimental curves do not conform to any of the formulae so far proposed. Better agreement is obtained if the concentration $\Theta$ in the formulae is replaced by $\Theta/\Theta_c$, where $\Theta_c$ is the concentration at which the material becomes conducting.

R.C.Kell

537.2 : 621.315.611

### 3723 THE DIELECTRIC BEHAVIOR OF SOLIDS EMBEDDED IN A HOMOGENEOUS MEDIUM. B.R.Eichbaum.

J. Electrochem. Soc., Vol. 106, No. 9, 804-9 (Sept., 1959).

Dielectric constant and $\tan\delta$ of powdered crystal phases of alumina, quartz, and wollastonite were determined. Since it is very difficult to obtain dielectric measurements of very fine (powdered) crystals, a technique of embedding the solids in a homogeneous medium was used. The relationship between particle shape and volume present in the composite to the dielectric properties of such fine powders was in accord with that indicated by Niesel's theory (1953).

537.2

### 3724 ON THE PHENOMENON OF THE CONTINUOUS CIRCULATION OF A POLAR LIQUID DIELECTRIC IN AN INHOMOGENEOUS ELECTRIC FIELD. G.H.Krawinkel.

Z. angew. Phys., Vol. 11, No. 8, 305-15 (Aug., 1959).

The experimental part describes a concentric cylinder capacitor whose electrodes are made of gauze. The liquid is drawn from the outer to the inner electrode when a high voltage is applied. The theory of this effect is calculated from first principles in great detail, including a calculation of the polarization due to dipole orientation. Agreement with experiment is excellent.

K.W.Plessner

537.2

### 3725 ELECTRONEGATIVE GASES IN DIELECTRICS CONTAINING VOIDS. A.Gemant.

Z. angew. Phys., Vol. 11, No. 6, 213-16 (June, 1959). In German.

Describes measurements made on dielectrics, particularly oil impregnated paper, in which internal discharges in small cavities ("voids") contribute to the electrical losses. The effect of electronegative gases, with relatively high dielectric strength, in reducing such losses was investigated. J.D.Craggs

## CURRENT ELECTRICITY

## ELECTROKINETICS

*(The study of solids through their electrical conduction properties is included under Solid-State Physics)*

537.3

### 3726 METHOD OF AMPLITUDE CONTROL OF A.C. SIGNALS. J.B.Cornwall.

J. sci. Instrum., Vol. 36, No. 9, 395-6 (Sept., 1959).

A circuit for controlling the r.m.s. value of an a.c. signal is analysed and practical results are discussed. The speed of response is such that for rates of change of 2.5% per second the output is controlled continuously within 1%. An alternative arrangement for maintaining, at a preset level, the peak value of repetitive pulses is also given.

537.3 : 621.316.722.1

### 3727 TIME-CONTROLLED UNIT-FUNCTION, CONSTANT-VOLTAGE GENERATOR. Y.Ettinger and H.Edels.

J. sci. Instrum., Vol. 36, No. 8, 362-4 (Aug., 1959).

The generator has a variable output amplitude from 40 to 1000 V with a rise time of 1 μs and constant for 150 μs. The output voltage is independent of current from 0 to 12 A and can be applied with an accuracy of ±1 μs. The generator consists of a source of high-capacity capacitors connected in parallel with non-inductive capacitors which supply the initial energy at a high rate. A mercury thyratron (type BT61A) with a special triggering circuit gives the necessary time control. By keeping the thyratron at a constant temperature, its appropriate volt–ampere characteristic shows that the voltage amplitude is maintained constant independent of variation in current output. A high rate of rise of the unit function is achieved by connecting a high-voltage auxiliary circuit between anode and cathode. Detailed circuit diagrams of the generator, etc., are given. The effects of temperature, accentuation of field due to additional space charge and oscillations on the voltage waveform are also discussed.

537.3 : 621.316.721

### 3728 THE THEORY OF BALLAST TUBES OR BARRETTERS. R.O.Jenkins.

Brit. J. appl. Phys., Vol. 9, No. 10, 391-4 (Oct., 1958).

The theory is based on a simple graphical method of solving the equation of thermal equilibrium of an electrically heated wire in a gas-filled enclosure. The results account for the main operating characteristics and have accurately predicted the ratings of various low voltage barretters. It is also shown why, in practice, barretters have always consisted of an iron wire in hydrogen.

537.3 : 539.2

### 3729 POSSIBLE EFFECT OF ELECTROMAGNETIC RADIATION ON THE ELECTRICAL CONDUCTIVITY OF ELECTRONIC CONDUCTORS. V.M.Eleonskii and P.S.Zȳryanov.

Fiz. Metallov i Metallovedenie, Vol. 6, No. 1, 171-2 (1958). In Russian.

Treats a system of electrons interacting through self-congruent e.m. fields.

537.3 : 551.5

### 3730 CONDUCTIVITY OF WEAKLY IONIZED AIR. N.Margenau, E.Dezlodzh and D.Stillinger.

Izv. Akad. Nauk SSSR, Ser. fiz., Vol. 23, No. 8, 1040-9 (1959). In Russian.

The classical derivation for the complex conductivity of an ionized medium, as a function of frequency, is considered first; discrepancies are discussed between the formula so obtained, depending on several approximations, and the experimental data. This leads to a new derivation of the conductivity formula (based on the Boltzmann statistics) and to reconsiderations of approximations usually made. In the last part of the paper the results obtained are applied to the case of upper atmospheric layers and Lorentz's approximation is compared with that based on the assumption of constant mean free path. Several graphs show conductivity computed on these two assumptions, as function of frequency for various values of the electron temperature. J.K.Skwirzynski

537.32 : 537.533

### 3731 THERMOELECTRIC COOLING OF PHOTOMULTIPLIERS.

E.A.Kolenko, Kh.V.Protopopov, D.G.Fleishman and V.G.Yur'ev.

Pribory i Tekh. Eksper., 1959, No. 3, 140-2 (May-June). In Russian.

Describes the use of semiconductor thermoelectric cells for the purpose of lowering the temperature inside a photomultiplier type FEU-11, hence reducing the background due to thermal emission from the photocathode and the dynodes. The "cold" junction makes good thermal contact with the glass near the photocathode, while the "hot" junction is in thermal contact with either an outside mass of metal or running water, depending on the use of the photomultiplier. The temperature was lowered from 24 to −5°C, causing the reduction of noise amplitude by a factor of 2.5.

J.M.Zarzycki

537.32 : 539.2

### 3732 THE IMPORTANCE OF EFFECTIVE MASSES AND MOBILITIES FOR THERMOELEMENTS. A.F.Ioffe.

Fiz. tverdogo Tela, Vol. 1, No. 10, 1627-9 (Oct., 1959). In Russian.

The role of the effective mass m* in determining the efficiency z of thermoelements is discussed. It is shown that, if the mobility u depends on the effective mass as $u \sim (m^*/m)^{-s}$, z increases with increasing m* if $s < \frac{3}{2}$, and increases with decreasing m* if $s > \frac{3}{2}$. R.B.Stinchcombe

537.32 : 539.2

### 3733 THE EFFICIENCY OF REFRIGERATING THERMO-ELEMENTS. E.K.Iordanishvili.

Fiz. tverdogo Tela, Vol. 1, No. 4, 654-5 (April, 1959). In Russian.

It is shown that the non-linear temperature distribution along the wires and the temperature variations of thermal e.m.f., electrical and thermal conductivities make the efficiency, $z = \alpha^2\sigma/\kappa$ a function of the temperature drop across the thermoelement. It is found experimentally that z decreases by 20-25% between $\Delta T = 5\text{-}10^0$ and $\Delta T = 60^0$. R.Berman

537.32 : 539.2

### 3734 CALCULATION OF EFFICIENCY OF THERMO-ELECTRIC DEVICES.

B.Sherman, R.R.Heikes and R.W.Ure, Jr.

J. appl. Phys., Vol.31, No.1, 1-16 (Jan., 1960).

A procedure has been developed for the exact calculation of the efficiency of thermoelectric generators and cooling devices in which the parameters of the materials have arbitrary temperature dependence. High-speed computer techniques are found necessary. Approximate methods are reviewed and their discussion is extended. A number of examples are worked out by both the exact and approximate methods. Comparison of these results show that the approximate methods agree with the exact method to about 5% in the case of power generation and to about 15% in the case of the refrigeration coefficient of performance. However, in the case of the maximum heat pumping rate, deviations as large as a factor of 2 are found.

## IONIZATION

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### 3735 IONIZATION POTENTIALS FOR $C_2F_4$, $C_2F_3Cl$, $C_2F_2Cl_2$ AND THE APPEARANCE POTENTIAL OF $CF_2^+$ FROM $C_2F_4$. J.L.Margrave.

J. chem. Phys., Vol. 31, No. 5, 1432 (Nov., 1959).

Ionization potentials for the chlorofluoroethylenes are tabulated. Using an assumed reaction mechanism for the formation of the $CF_2^+$ ion, $\Delta H(CF_2)$ is calculated. G.I.W.Llewelyn

537.56

### 3736 THRESHOLD LAW FOR THE PROBABILITY OF EXCITATION BY ELECTRON IMPACT.

F.H.Dorman, J.D.Morrison and A.J.C.Nicholson.

J. chem. Phys., Vol. 32, No. 2, 378-84 (Feb., 1960).

The threshold law for processes of excitation is difficult to measure directly and lack of experimental evidence has prevented a choice being made between different theoretical treatments. The ionization efficiency curves for the ion-pair processes, $I^+$ from $I_2$, $O^+$ from $O_2$, and $C^+$ from CO, and for what is here claimed to be auto-ionization in $N_2^+$ and $O_2^+$ have been measured. It is shown that these curves measure excitation probabilities and that the threshold law is in all cases a step function of the energy. The implications of this with regard to the assignment of dissociation products and the measurement of appearance potentials are discussed.

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### 3737 THRESHOLD IONIZATION OF HCl BY ELECTRON IMPACT. R.E.Fox.

J. chem. Phys., Vol. 32, No. 2, 385-6 (Feb., 1960).

The ionization of HCl by electron impact was studied in a mass spectrometer with a pseudomonoenergetic electron beam. The ionization potential of HCl was determined as 12.56 ± 0.1 eV. The ionization curve at threshold exhibits excessive curvature which is attributed to the $^2\Pi_i$ doublet ground states of the ion estimated to be separated by 0.3 eV. A sharp change in slope of the ionization curve at 1.6 eV above threshold is attributed to the onset of ionization of the A $^2\Sigma^+$ excited state of $HCl^+$.

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### 3738 ELECTRON IMPACT STUDIES OF AROMATIC HYDROCARBONS. I. BENZENE, NAPHTHALENE, ANTHRACENE, AND PHENANTHRENE. M.E.Wacks and V.H.Dibeler.

J. chem. Phys., Vol. 31, No. 6, 1557-62 (Dec., 1959).

A systematic survey of ionization—dissociation processes of fused-ring aromatic compounds is initiated. Mass spectra and appearance potentials of the singly and doubly charged molecule ions are reported. The observed ionization potentials of benzene ($9.3_8$ eV), naphthalene ($8.2_6$ eV), anthracene ($7.5_5$ eV), and phenanthrene ($8.0_3$ eV) are compared with available spectroscopic data, with values obtained from molecular orbital calculations, and with other electron impact data. The empirical method of group equivalents is extended to the calculation of the ionization potentials of the fused-ring aromatic compounds.

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### 3739 NEGATIVE ION FORMATION IN $NO_2$ BY ELECTRON ATTACHMENT. R.E.Fox.

J. chem. Phys., Vol. 32, No. 1, 285-7 (Jan., 1960).

This was studied at low pressures as a function of electron energy in a mass spectrometer. The principle ion formed is found to be $O^-$ which onsets at 1.35 ± 0.05 eV and whose apparent maximum occurs at 1.90 eV. Comparison of the peak shape with the electron energy distribution indicates the maximum cross-section occurs within 0.1 eV of threshold. The $NO_2^-$ ion whose maximum cross-section is only about one-hundredth that for $O^-$ appears to have the same energy dependence. Crude estimates of the cross-section for attachment yield order of magnitude values of $10^{-18}$ cm² for $O^-$ and $10^{-20}$ cm² for $NO_2^-$.

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### 3640 NEGATIVE ION MASS SPECTRA OF HYDROCARBONS AND ALCOHOLS. C.E.Melton and P.S.Rudolph.

J. chem. Phys., Vol. 31, No. 6, 1485-8 (Dec., 1959).

The complete negative ion mass spectra and relative sensitivity for positive and negative ion formation in various organic compounds are reported for the first time. These compounds include methane, the $C_2^-$ hydrocarbons, n-butane, and all of the alkyl alcohols through the butyls. A limited comparison of the observed ionic patterns with molecular structure and chemical properties manifests a correlation. Relative sensitivities for positive and negative ion formation in these compounds show that formation of positive ions is about four orders of magnitude more probable than formation of negative ions under the conditions used in this study.

537.56 : 523.6

FORMATION OF $CO^+$ IONS IN COMETS. See Abstr. 3415

537.56

### 3741 MASS SPECTRUM OF PROPANE: ISOTOPE EFFECT AND METASTABLE IONS.

A.Kropf, E.M.Eyring, A.L.Wahrhaftig and H.Eyring.

J. chem. Phys., Vol. 32, No. 1, 149-57 (Jan., 1960).

The mass spectra of propane and of propane-2,2-$d_2$ are calculated assuming that the mass spectra results from successive and competing unimolecular reactions following initial vertical ionization of the parent molecules. Reasonable agreement with experiment is found for the change in mass spectral pattern with deuterium substitution. The metastable ion peaks are shown to be a normal part of the mass spectrum.

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### 3742 KINETICS OF IONS IN GASES.

I.Popescu.

Rev. de Physique (Bucarest), Vol. 4, No. 2, 199-209 (1959).

Describes an experimental retarding-field method from which it is possible to obtain the collision cross-section Q, drift velocity $v_0$ and energy distribution of ions at high values of E/p (E the electric field, p the gas pressure). On the assumption that charge transfer is the predominant process, values of Q and $v_0$ are computed for $Hg^+$ in Hg for $1000 < E/p < 33\,300$ V/cm/mm Hg. The motion of $K^+$ in Hg is discussed to illustrate how the method may be used when elastic collisions predominate. J.Dutton

## ELECTRIC DISCHARGES

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3743

### THE EFFECT OF TEMPERATURE ON PRE-BREAKDOWN CURRENTS IN COMPRESSED GASES.

A.Boulloud.

C.R.Acad. Sci. (Paris), Vol. 249, No. 14, 1202-4 (Oct. 5, 1959).
In French.

A brief note describing measurements of prebreakdown currents between, e.g., stainless steel electrodes. Temperatures varied from about 25 to $50^\circ$C, and the corresponding currents from $\sim 5\times10^{-10}$ to $4\times10^{-8}$ A. The currents increase with temperature. Results are shown graphically and the effect is briefly discussed.

J.D.Craggs

537.552 : 621.316.933

3744

### SURGE DIVERTERS USING TRIGATRONS.

T.E.Broadbent and A.Fernandez.

J. sci. Instrum., Vol. 36, No. 11, 452-7 (Nov., 1959).

The work described shows that a single-stage trigatron surge diverter is a simple and effective method of removing the voltage from a specimen once the breakdown initiation process occurs. With solid specimens, the device is of value in enabling breakdown tracks to be observed, whilst with gaseous specimens the diverter can conveniently be used in the study of the filamentary discharges which occur during the breakdown initiation process. The results of detailed experiments designed to investigate the performance of trigatron surge diverters at direct voltages up to 1000 kV are discussed.

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### PROCESSES IN THE ELECTRODE SPACES OF SHORT-TIME HIGH-INTENSITY ELECTRIC DISCHARGES.

V.Hermoch.

Czech. J. Phys., Vol. 9, No. 4, 505-11 (1959). In Russian.

The conditions and causes of the interrupted emission of vapours of the electrode material are discussed on the basis of earlier and new observations.

537.52

3746

### BEHAVIOUR OF A MIXTURE OF NITROUS OXIDE AND HYDROGEN UNDER SPARK DISCHARGE.

J.N.Sahay.

Curr. Sci., Vol. 28, No. 8, 324-5 (Aug., 1959).

Experimental study of the decrease in pressure resulting from spark discharges in mixtures of $N_2O$ and $H_2$ of various initial compositions and pressures. In all cases the pressure decreased to a constant value consistent with a thermal reaction.

J.Dutton

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3747

### THE TEMPERATURE OF ELECTRODE VAPOURS IN A SPARK DISCHARGE.

N.K.Sukhodrev and S.L.Mandel'shtam.

Optika i Spektrosk., Vol. 6, No. 6, 723-8 (June, 1959). In Russian.

Deals with determination of temperatures in hotter parts of electrode vapour clouds in a spark discharge. Al III, Sn IV and Si IV lines were used. The temperatures deduced from the Sn IV lines were $\sim 28\,000^\circ$K, from the Al III lines they were $30\,000^\circ$K and from the Si IV lines they were $35\,000^\circ$K. Because of high scatter of the results, it was impossible to say whether the differences between these three temperatures were real or accidental.

A.Tybulewicz

537.52 : 621.314.653

3748

### SIMPLIFIED REPRESENTATIONS ON THE FIRING CHARACTERISTICS OF VIBRATIONAL-IGNITOR TUBES.

S.Okanishi and H.Kanamori.

J. Phys. Soc. Japan, Vol. 14, No. 4, 542 (April, 1959).

Describes experiments on the firing characteristics of mercury-pool low-pressure arc tubes (ignitrons). Resistive and inductive loads were studied. Data for firing probabilities are plotted graphically as a function of ignitor current.

J.D.Craggs

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3749

### THE TIME REQUIRED FOR ESTABLISHMENT OF THERMODYNAMIC EQUILIBRIUM IN THE PLASMA OF AN ARC DISCHARGE.

V.K.Prokof'ev, D.B.Gurevich, I.M.Belousova and Yu. A.Snigirev.

Optika i Spektrosk., Vol. 7, No. 1, 14-20 (July, 1959). In Russian.

The authors measured the time required for establishment of thermodynamic equilibrium in a 5-15 A, 45 V d.c. arc, burning between carbon electrodes in air at atmospheric pressure, using short (10-25μsec) pulses of 80-200 A across the arc gap. Establishment of thermodynamic equilibrium conditions after a pulse was taken to be that moment at which the temperatures $T_{exc}$, $T_{vibr}$ and $T_{rot}$ became equal; $T_{exc}$ was the temperature deduced from the relative intensities of the atomic lines Fe I 5269.5 and 4325.76 A, $T_{vibr}$ was the temperature deduced from the ratio of the intensities of unresolved 0—1 and 1—2 CN band edges at 4216.0 and 4197.2 A, $T_{rot}$ was the temperature deduced from the distribution of intensities in an unresolved 0—1 CN rotational band with an edge at 4216.0 A. Spectral measurements were made with a four-channel photoelectric spectrometer. The time required for establishment of thermodynamic equilibrium was found to be 20-25μsec.

A.Tybulewicz

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### SOME FEATURES OF ARC DISCHARGES IN AN INERT GAS ATMOSPHERE.

V.N.Kolesnikov and N.N.Sobolev.

Radiotekhnika i Elektronika, Vol. 4, No. 8, 1286-8 (Aug., 1959).
In Russian.

See Abstr. 9674 (1959). Gives additional experimental results leading to the conclusion that the introduction of metal atoms (Ba, Be, Li) into an arc burning in a helium or argon atmosphere produces a definite shift towards thermal equilibrium.

D.E.Brown

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3751

### APPLICABILITY OF THE COWAN AND DIEKE FUNCTION TO A DIRECT-CURRENT ARC.

Yu.A.Sherstkov.

Optika i Spektrosk., Vol. 6, No. 6, 817-18 (June, 1959). In Russian.

Reports an experimental check of the correctness of the Cowan and Dieke function (Abstr.3232 of 1948) when used to describe excitation processes in a d.c. arc. The distribution of intensities was obtained in the plane of the central cross-section of the arc for resonance lines of barium and strontium atoms and ions, as well as the radial distribution of temperature determined using Cu I lines at 5105 and 5218 A. Comparing the experimental data and the theoretical curves, it was found that the Cowan and Dieke function can, in general, be used to calculate the shape of lines emitted in a direct-current arc, but if this function is applied to resonance lines of atoms with low ionization potentials, the errors may reach 20%.

A.Tybulewicz

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3752

### THE EFFECT OF THE CATHODE REGION ON THE DYNAMIC PROPERTIES OF A GLOW DISCHARGE IN HYDROGEN.

V.Krejčí.

Czech. J. Phys., Vol. 8, No. 6, 689-98 (1958). In Russian.

A glow discharge was maintained by d.c. in a tube containing spectroscopically pure hydrogen and short voltage pulses. At pressures 0.3- 1.5 mm Hg the discharge enters into periodically damped oscillations. The frequency of the oscillations was measured as a function of various circuit parameters, e.g. capacity of the condenser across the discharge. Variations in the character of these oscillations with change of cathode surface suggests that these changes are caused by the influence of the energies amassed in the cathode region of the discharge. In order to study the theoretical aspects of the problem, R, L, C equivalent circuits are proposed for the positive column, the cathode region and the external circuit, and the basic equations constructed and solved. Theory and experiment are in satisfactory qualitative agreement.

C.R.S.Manders

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### THE SUCCESSIVE PRODUCTION OF STRIATIONS IN A GLOW DISCHARGE IN HYDROGEN.

L. Pekárek.

Czech. J. Phys., Vol. 8, No. 6, 699-703 (1958).

Describes experiments on striations moving from cathode to anode in hydrogen discharges ($\sim$ 3 mm Hg pressure, 1-5 mA current). The results are briefly discussed.

J.D.Craggs

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3754

### THE INFLUENCE OF A STRONG HIGH-FREQUENCY FIELD ON THE STRATIFICATION OF THE POSITIVE COLUMN OF A D.C. GLOW DISCHARGE.

M.Šícha.

Czech. J. Phys., Vol. 9, No. 4, 495-504 (1959). In Russian.

An experimental study was made of the damping of moving striations by a strong h.f. field. The results are in agreement with existing theories on the production and mechanism of propagation of moving striations. Apart from the process of damping, the paper also describes the standing stratification of the positive column of a d.c. discharge as a result of a superposed h.f. discharge.

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### 3755 STEADY STATE SOLUTIONS OF THE RADIOFREQUENCY DISCHARGE WITH FLOW. M.F.Romig.

Phys. of Fluids, Vol. 3, No. 1, 129-33 (Jan.-Feb., 1960).

The electron density distribution and diffusion length have been investigated for a steady-state, diffusion-controlled radiofrequency discharge acting over a finite portion of an infinite cylinder in which there is a uniform axial gas flow. This model simulates to some extent the flow in a plasma wind tunnel. A qualitative relationship is obtained for the influence of active cylinder length and gas velocity parameter on the diffusion length. The effect of these parameters on the electric field necessary to sustain the discharge is also discussed. It is shown that the peak of the electron density distribution shifts downstream with increasing gas velocity, but never leaves the region of production. A numerical example is calculated for the case of helium, indicating that while there is moderate effect on breakdown parameters, the ambipolar case may be changed considerably by the presence of flow.

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METAL WIRE EXPLOSIONS CAUSED BY ELECTRIC CURRENTS. See Abstr. 2850

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### 3756 EFFECT OF WATER VAPOR ON THE DISSOCIATION OF HYDROGEN IN AN ELECTRICAL DISCHARGE.

T.M.Shaw.

J. chem. Phys., Vol. 31, No. 4, 1142-3 (Oct., 1959).

Experiments were carried out with a 3000 Mc/s discharge in hydrogen. A high yield of atomic hydrogen, measured by both electron spin resonance and calorimetric techniques, was only obtained in the presence of small amounts ($< 0.1\%$) of oxygen and/or water vapour. J.D.Craggs

## PLASMA

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### 3757 SOME THEORETICAL ASPECTS OF MAGNETOHYDRODYNAMICS AND THERMONUCLEAR FUSION.

R.Lüst.

Nuovo Cimento Suppl., Vol. 13, No. 1, 330-5 (1959).

The problem of confining a plasma in a magnetic field is considered from the standpoints of hydromagnetic pressure balance, stability and individual particle losses. Previous work on these topics is considered together with some new work along similar lines by the Göttingen group. A.H.Gabriel

537.56

### 3758 COLLISION-FREE HEATING OF PLASMA. F.Schneider.

Z. angew. Phys., Vol. 12, No. 1, 5-7 (Jan., 1960). In German.

A brief discussion of methods already proposed for raising a plasma to thermonuclear temperatures is followed by a proposal to impart to the particles of the plasma backward and forward increments of speed ±W, the probabilities of +W and −W being equal. Analysis shows that heat power developed is proportional to the average speed and to $W^2$. Estimates of the a.c. fields required to realize such a system by the movement of containing magnetic "walls", and a proposed scheme employing a number of damped oscillators, are presented. B.Meltzer

537.56 : 539.17

### 3759 TRANSIENT TEMPERATURE VARIATIONS DURING THE SELF-HEATING OF A PLASMA BY THERMONUCLEAR REACTIONS. H.D.Greyber.

Phys. Rev., Vol. 117, No. 1, 43-4 (Jan. 1, 1960).

The ion and electron temperature variations in an idealized controlled thermonuclear reactor burning various ratios of deuterium and tritium are calculated. The variation in the fraction of energy deposited to the nuclear and electron gases with temperature is specifically included. One qualitative result is that it would be unsafe to assume nuclear temperature always equal to or greater than electron temperature for a nuclearly reacting plasma with tritium concentration greater than 10%.

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### 3760 THE USE OF MAGNETIC PROBES IN PLASMA DIAGNOSTICS. R.H.Lovberg.

Ann. Phys. (New York), Vol. 8, No. 3, 311-24 (Nov.,1959).

The technique of magnetic probing of magnetohydrodynamic systems is examined in relation to other diagnostic means. Procedures for extracting plasma data from magnetic field plots are outlined, together with specific examples. Limitations of this type of measurement, particularly for very hot plasmas, are discussed.

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### 3761 ON THE POSSIBILITY OF AMPLIFYING THE ELECTRON DENSITY IN A MAGNETIC BOTTLE.

J.L.Delcroix and D.Quemada.

C.R. Acad. Sci. (Paris), Vol. 249, No. 11, 994-6, (Sept. 14, 1959). In French.

Discusses the use of cyclotron resonance for trapping electrons in a magnetic mirror machine. Axially injected electrons acquire an increment of azimuthal velocity at each traversal of an r.f. field placed between the mirrors. When successive increments are in phase, trapping occurs; but when the increments are added at random, the velocity vectors diffuse into the escape cones of the mirrors. Gives details of a proposed experiment. R.S.Pease

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### 3762 ON THE POSSIBILITY OF FORMING A THERMONUCLEAR PLASMA BY INJECTING IONS INTO A MAGNETIC MIRROR CONFIGURATION.

F.Prévot, P.Hubert and C.Gourdon.

C.R. Acad. Sci. (Paris), Vol. 249, No. 11, 997-9 (Sept. 14, 1959). In French.

Outlines a proposal to accelerate molecular ions into a mirror machine from an annular source placed round it. Trapping is by dissociation of the ions in, for example, a carbon arc on the axis of mirrors. R.S.Pease

537.56

### 3763 PLASMA COMFINEMENT BY EXTERNAL MAGNETIC FIELDS. J.G.Linhart.

Nuovo Cimento Suppl., Vol. 13, No. 1, 257-80 (1959).

The energy loss due to particle losses from a magnetic bottle are calculated. These are much greater if "flute instabilities" can form, which they cannot in a cusp geometry. For a stable system, the particle loss is shown to be negligible for a D-T reactor at a temperature of $10^9$ °K. The conditions under which runaway electrons can be produced are derived. Equations for wave propagation on a cylinder of plasma are obtained for the three cases in which the confining field is longitudinal, azimuthal and helical. A.H.Gabriel

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### 3764 BEHAVIOUR OF A HIGH-FREQUENCY PLASMA IN THE PRESENCE OF A MAGNETIC FIELD. R.Geller.

C.R. Acad Sci. (Paris), Vol. 250, No. 2, 314-16 (Jan. 11, 1960). In French.

An instability is observed when the resonance frequency of electrons in the plasma is approximately equal to the electron gyromagnetic frequency. C.G.Morgan

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### 3765 THE CONNECTION BETWEEN THE CHARACTERISTICS OF VERY HIGH-FREQUENCY AND CONSTANT CURRENTS IN A GAS. V.E.Golant.

Izv. Akad. Nauk SSSR, Ser. fiz., Vol. 23, No. 8, 958-61 (1959). In Russian.

Conditions are formulated under which there is a correspondence between the high-frequency and d.c. characteristics of an ionized gas. These conditions are the conditions for the anisotropic components of the electron distributions to be proportional in the two cases. The correspondence is illustrated by correlating experimental d.c. and h.f. results for the dependence on pressure of the critical field for breakdown of inert gases. O.Penrose

537.56

### 3766 PROPAGATION AND PRODUCTION OF ELECTROMAGNETIC WAVES IN A PLASMA. R.Gallet.

Nuovo Cimento Suppl., Vol. 13, No. 1, 234-55 (1959).

A number of non-thermal sources of electromagnetic waves are described, and the theory of propagation in a plasma is derived. The emission of radio waves from Jupiter is considered as a special case which has not yet been solved. The conditions for propagation of electromagnetic waves by plasma oscillations are examined with particular reference to the sun. It is found that such propagation is possible at low efficiency in the presence of a weak magnetic field, but is dependent on collisions and departures of the velocity distribution from the Maxwellian. A.H.Gabriel

537.56 : 538.56

INTERACTION OF RADIO-WAVES PROPAGATING IN A PLASMA. See Abstr. 2444

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### 3767 PROPAGATION OF PLASMA WAVES ACROSS A DENSITY DISCONTINUITY. A.H.Kritz and D.Mintzer.

Phys. Rev., Vol. 117, No. 2, 382-6 (Jan. 15, 1960).

The linearized plasma equations and the boundary conditions to be satisfied across a surface of density discontinuity are considered. It is shown that an incident longitudinal plasma wave generates reflected and transmitted transverse plasma waves, as well as reflected and transmitted longitudinal waves. The inverse process also occurs. The transverse waves are generated only when the longitudinal wave is almost normally incident; in the inverse process, the generated longitudinal waves are propagated normal to the boundary.

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### 3768 ABSORPTION OF PLASMA WAVES. T.H.Stix.

Phys. of Fluids, Vol. 3, No. 1, 19-32 (Jan.-Feb., 1960).

The propagation of waves through a plasma, wherein the density and/or magnetic field strength are slowly varying functions of position is discussed. If the local propagation constant, $k_x$, is a slowly varying function of x, the adiabatic approximation will be valid. However, $k_x^2$ may pass through zero as a function of x. Using the WKB linear turning point connection formulas, examination shows that an incoming plasma wave is totally reflected in the region where $k_x^2 \cong 0$. A similar analysis for the case where $k_x^2$ is a singular function of x shows that absorption of an incoming wave occurs in the vicinity of the singularity. Such singular behaviour in $k_x^2$ can occur for propagation along the magnetic field when the wave frequency is equal to the local ion or electron cyclotron frequency. For propagation transverse to the magnetic field, an apparent singularity occurs at a frequency somewhat below the ion cyclotron frequency, and at the two hybrid frequencies of Auer, Hurwitz, and Miller. A detailed examination, including higher order effects in electron mass ÷ ion mass, finite electron and ion temperatures, and ion—ion and ion—electron collisions shows that the absorption will take place at the apparent singularity only if the physical damping processes are strong enough to swamp the reactive effects of the higher order corrections. Otherwise the higher order reactive effects introduce a new propagation mode into the dispersion equation with a root which, in the vicinity of the apparent singularity, is conjugate to the root of the original mode. Partial or total reflection now occurs at the apparent singularity instead of absorption. It is, however, conjectured that some of the original mode energy may be reflected into the new mode. As the new mode recedes from the region of the apparent singularity, its wavelength can become comparable to the particle Larmor radius. Energy in this mode may then be absorbed by phase-mixing processes which are of high order in the quantity (Larmor radius ÷ wavelength). Wave reflection from the apparent singularities will then heat ions in the case of the transverse ion cyclotron mode, and electrons in the case of the upper hybrid frequency.

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### 3769 TRANSVERSE COMPRESSION WAVES IN A STABILIZED DISCHARGE. D.Reagan.

Phys. of Fluids, Vol. 3, No. 1, 33-9 (Jan.-Feb., 1960).

An electric discharge which is compressed by its own magnetic field, and "stabilized" by means of an axial magnetic field, can have transverse wave motions which cause its periodic compression and expansion. This kind of motion can cause the heating of the ions in the discharge. The simplest of these wave modes are described and an estimate is given of the power available to the waves as a result of the interaction of the electrons in the discharge with an axial electric field. This interaction can cause the attenuation or spontaneous growth of the waves, depending upon the circumstances. It is likely that in high current gas discharge experiments there are examples of growing and decaying waves of this type.

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### 3770 ASYMPTOTIC CONTRIBUTION TO NON-LINEAR THEORY OF PLASMA OSCILLATIONS. L.Gold.

J. Electronics and Control, Vol. 6, No. 6, 548-9 (June, 1959).

Determines the value of an integration constant, which was left undetermined in the non-linear plasma theory of Amer (Abstr. 8068 of 1958), by finding the solution of his equation for the charge density valid near the time origin. B.Meltzer

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### 3771 COLLISION DAMPING OF SPACE-CHARGE WAVES IN A PLASMA. S.V.Yadavalli.

J. Electronics and Control, Vol. 7, No. 3, 261-7 (Sept., 1959).

The general determinantal equation applicable to the propagation of space-charge waves, including the effect of collisions (in the absence of a velocity distribution), is derived. Solutions of the equation under different conditions suggest (a) a possible method of noise reduction in beam-type tubes, and (b) a possible procedure for the determination of collision frequency and particle density in a plasma as typically found in some experiments on fusion research.

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### 3772 RADIO EMISSION BY PLASMA OSCILLATIONS IN NONUNIFORM PLASMAS. D.A.Tidman.

Phys. Rev., Vol. 117, No. 2, 366-74 (Jan. 15, 1960).

Equations of motion for small-amplitude plasma oscillations interacting with the electromagnetic field in slowly varying density or temperature gradients are set up. A calculation is then made of the radio noise excited by a wave packet of plasma oscillations traversing such gradients using the WKB approximation. A similar calculation is also made for a density discontinuity.

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### 3773 CYCLOTRON RADIATION FROM A HOT PLASMA. W.E.Drummond and M.N.Rosenbluth.

Phys. of Fluids, Vol. 3, No. 1, 45-50 (Jan.-Feb., 1960).

In their Geneva paper, Trubnikov and Kudryavtsev calculated the cyclotron radiation from a hot plasma. In doing this, the assumption was made that the individual particles radiated as though they were in a vacuum. This approximation was investigated by calculating the absorption length directly from the Boltzmann equation, and it is found that this assumption is correct whenever $(\omega_p/\omega_e)^2 \ll m^2$, where m is the harmonic number of the radiation in question, $\omega_p$ is the plasma frequency, and $\omega_e$ is the cyclotron frequency. For a contained plasma, the left hand side of this inequality is of the order of magnitude of one, and thus the inequality is well satisfied for the dominant radiation from a plasma at high temperature. The angular independence of the absorption coefficient has been calculated, and this together with a more careful examination of the mechanism of thermonuclear energy transfer to the electrons, leads to a modification of the results presented by Trubnikov and Kudryavtsev at Geneva. In addition, it is shown that by the use of reflectors the critical size can be reduced by two orders of magnitude.

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### 3774 TEST PARTICLES IN A COMPLETELY IONIZED PLASMA. N.Rostoker and M.N.Rosenbluth.

Phys. of Fluids, Vol. 3, No. 1, 1-14 (Jan.-Feb., 1950).

Starting from the Liouville equation, a chain of equations is obtained by integrating out the coordinates of all but one, two, etc., particles. One "test" particle is singled out initially. All other "field" particles are assumed to be initially in thermal equilibrium. In the absence of external fields, the chain of equations is solved by expanding in terms of the parameter $g = 1/nL_D^3$. For the time evolution of the distribution function of the test particle, an equation is obtained whose asymptotic form is of the usual Fokker—Planck type. It is characterized by a frictional-drag force that decelerates the particle, and a fluctuation tensor that produces acceleration and diffusion in velocity space. The expressions for these quantities contain contributions from Coulomb collisions and the emission and absorption of plasma waves. By consideration of a Maxwell distribution of test particles, the total plasma-wave emission is determined. It is related to Landau's damping by Kirchoff's law. When there is a constant external magnetic field, the problem is characterized by the parameter g, and also the parameter $\lambda = \omega_c/\omega_p$. The calculation is made by expanding in terms of g, but all orders of $\lambda$ are retained. To the lowest order in g, the frictional drag and fluctuation tensor are slowly varying functions of $\lambda$. When $\lambda \ll 1$, the modification of of the collisional-drag force due to the magnetic field, is negligible.

There is a significant change in the properties of plasma waves of wavelength greater than the Larmor radius which modifies the force due to plasma-wave emission. When $\lambda \gg 1$, the force due to plasma-wave emission disappears. The collisional force is altered to the extent that the maximum impact parameter is sometimes the Larmor radius instead of the Debye length, or something in between. In the case of a slow ion moving perpendicular to the field, the collisional force is of a qualitatively different form. In addition to the drag force antiparallel to the velocity of the particle, there is a collisional force antiparallel to the Lorentz force. The force arises because the particle and its shield cloud are spiralling about field lines. The force on the particle is equal and opposite to the centripetal force acting on the "shield cloud". It is much smaller than the Lorentz force.

537.56

3775 ELECTRON AND ION RUNAWAY IN A FULLY IONIZED GAS: II. H.Dreicer.

Phys. Rev., Vol. 117, No. 2, 329-43 (Jan. 15, 1960).

The treatment presented in Pt I (Abstr. 13400 of 1959) is extended to give a more exact estimate of the particle runaway rate in a fully ionized gas under the action of a weak applied electric field. By analysing the motion of particles in various regions of velocity space, it is shown that in any weak applied electric field some particles will always run away. The rate at which this occurs is determined by the flow of particles from the collision-dominated to the electric-field-dominated region of velocity space. The probability, $Q(\tau)$, of electron runaway as a function of time is calculated with the help of the Boltzmann—Fokker—Planck equation and can be expressed in the form $Q(\tau) = 1 - \exp(-\lambda_1\tau)$. The runaway rate, $\lambda_1$, is presented as a function of applied electric field, and the plasma temperature and density. It exceeds by several orders of magnitude the rate recently proposed by Harrison. The runaway rate for positive ions is shown to be exceedingly small compared to $\lambda_1$, in the circumstances usually encountered. A brief discussion is devoted to the experimental evidence, the effects of magnetic fields, and the excitation of plasma instabilities. The correction which particle runaway introduces in the equation of pressure balance is presented for the case of a static pinched discharge.

537.56

3776 IRREVERSIBLE PROCESSES IN IONIZED GASES. R.Balescu.

Phys. of Fluids, Vol. 3, No. 1, 52-63 (Jan.-Feb., 1960).

The general theory of irreversible processes, developed by Prigogine and Balescu (see Abstr. 8441 of 1957), is applied to the case of long range interactions in ionized gases. A similar diagram technique permits the systematic selection of all the contributions to the evolution of the distribution function, to an order of approximation equivalent to Debye's equilibrium theory. The infinite series which appear in this way can be summed exactly. The resulting evolution equations have a clear physical significance: they describe interactions of "quasi particles", which are electrons or ions "dressed" by their polarization clouds. These clouds are not a permanent feature, as in equilibrium theory, but have a nonequilibrium, changing shape, distorted by the motions of the particles. From the mathematical point of view, these equations exhibit a new type of nonlinearity, which is very directly related to the collective nature of the interactions.

537.56

3777 INSTABILITY OF CONTRA-STREAMING PLASMAS. P.J.Kellogg and H.Liemohn.

Phys. of Fluids, Vol. 3, No. 1, 40-4 (Jan.-Feb., 1960).

The problem of instabilities in colliding ionized hydrogen beams, which has been treated by Kahn (Abstr. 2002 of 1959) and Parker (Abstr. 4739 of 1959) in the special case of zero temperature, is solved for the nonzero temperature case by taking Maxwell distributions for the equilibrium density functions. At sufficiently high temperature it is found that the random thermal motion will prevent growing oscillations. The boundary between the stable and unstable regions is plotted as a function of energy and density parameters. Certain phenomena associated with solar particle streams are discussed in terms of these results.

537.56 : 535.32

3778 **MEASUREMENT OF THE REFRACTIVE INDEX OF A PLASMA IN THE OPTICAL REGION.**

U.Ascoli-Bartoli and F.Rasetti.

Nuovo Cimento, Vol. 13, No. 6, 1296-9 (Sept. 16, 1959).

A Jamin interferometer is used to measure the change in refractive index produced when an r.f. discharge is formed in a column of argon; from this the electron density may be estimated. Full details are given of the experimental procedure and an accuracy of about 1% is claimed. P.A.Young

537.56

3779 7 kW PLASMA JET FOR LABORATORY USE. A.B.Osborn.

J. sci. Instrum., Vol. 36, No. 7, 317-19 (July, 1959).

The usual form of cathode for plasma jet apparatus is a graphite disk having a central hole through which the jet of plasma emerges. Burning of the graphite continuously enlarges the hole and necessitates frequent renewal of the disk. For small-scale work, this inconvenience can be avoided by replacing the disk with a metal orifice plate (electrically neutral), and by using an external graphite rod as cathode. With the 7 kW apparatus described, the jet of plasma produced is some 5 cm long, with a maximum core temperature believed to be about 10 000°C. The maximum rate of heat transfer to a surface of 6 mm diameter is approximately 300 cal $cm^{-2}sec.^{-1}$. By injecting various gases the atmosphere of the arc can be modified. Argon is notable for reducing the arc voltage by about 30%, and for suppressing the usual crater formation at the anode.

## ELECTRON EMISSION
## ELECTRON BEAMS

537.533

3780 INVESTIGATIONS OF EXOELECTRONS FROM EVAPORATED METALLIC LAYERS AND SOME NON-METALLIC SURFACES. J.Wüstenhagen.

Z. Naturforsch., Vol. 14a, No. 7, 634-41 (July 1959). In German.

A glass system with grease-free joints and windows is used for examination of exoelectron emission from freshly evaporated metal layers, a secondary-electron multiplier being used for detection of the electrons. Aluminium shows no emission in a vacuum of $4 \times 10^{-7}$ Torr. On admission of oxygen an emission occurs which decays with time but no effect is found with nitrogen. A freshly evaporated surface must be heated with oxygen to obtain emission. If oxygen is pumped away a time-dependent but pressure-independent decay of emission is observed. A second section of the paper deals with the emission from X-ray and electron-irradiated, silver-activated NaCl crystals. The emission does not depend on the surrounding gas but depends on the silver content which is not explicable on the basis of previous theoretical models. G.F.J.Garlick

537.533 : 621.327.4.212.63

3781 ON THE RESEARCH AND DEVELOPMENT OF ELECTRON EMITTING SUBSTANCES FOR GAS DISCHARGES. D.M.Speros.

J. Electrochem. Soc., Vol. 106, No. 9, 791-9 (Sept., 1959).

Criteria for the stability and chemical behaviour of electron-emitting cathode materials in gas discharges are obtained by means of thermodynamics. Theoretical analysis is supplemented by means of experimental methods intended for the study of processes at elevated temperatures, such as thermogravimetry and differential thermal analysis. The application of the above permits some insight into the processes of formation, activation, and detrition of electron emitting compositions, guiding the development of a number of improved cathodes.

537.533

3782 FIELD EMISSION FROM SEMICONDUCTORS. G.Busch and T.Fischer.

Brown Boveri Rev., Vol. 45, No. 11-12, 532-9 (Nov.-Dec., 1958).

A review of the theory and current experimental work.

537.533

3783 TIME DEPENDENCE OF THE FIELD-EMISSION CURRENT FROM A TUNGSTEN POINT.

L.Eckertová and K.Mašek.

Czech. J. Phys., Vol. 9, No. 4, 512-16 (1959). In Russian.

A description is given of the increase in the electron current with time after the voltage on the electron projector has been switched off. It is assumed that the increase in current is caused by desorption of the adsorbed layers, which increases the work function. Hypotheses on the mechanism of desorption are put forward.

537.533

3784 THE INFLUENCE OF SPACE CHARGE ON AUTO-ELECTRONIC EMISSION. A.S.Kompaneets.
Dokl. Akad. Nauk SSSR, Vol. 128, No. 6, 1160-2 (Oct. 21, 1959). In Russian.

The effect of space charge on field emission at current densities of the order of $10^7$ A/cm is discussed, considering spherical geometry (see Abstr. 2469 of 1954 for plane geometry). For large current densities, introduction of an image force correction function to the current density equation is recommended. J.M.Zarzycki

537.533 : 539.27

3785 EVIDENCE OF FLUCTUATING CHARGES IN THIN COLLODION FILMS DURING ELECTRON IRRADIATION.
H.Mahl and W.Weitsch.
Naturwissenschaften, Vol. 46, No. 16, 487-8 (1959). In German.

Thin films of "Formvar" or collodion were placed at the intermediate image position of an electrostatic microscope so as to form a shadow picture on the final screen. By the use of a suitable "Schlieren" aperture the presence of fluctuating electric charges on the film was detected. These charges were not present on metallized or on carbon films. The fluctuation of charge is ascribed to field emission from the film. A.E.I. Research Laboratory

537.533

3786 THERMIONIC PROPERTIES OF URANIUM.
E.G.Rauh and R.J.Thorn.
J. chem. Phys., Vol. 31, No. 6, 1481-5 (Dec., 1959).

Thermionic measurements were made on uranium metal in the form of drawn wire and on films of uranium deposited on tungsten by evaporation in ultrahigh vacua. Measurements of the emission current as a function of accelerating potential and of the work function of the bulk material indicated that the surface was never completely freed of oxide. Measurements of the work function and emission constant A as a function of the thickness of the evaporated films showed both $\phi$ and A to increase with increasing depth of deposit up to 15 atom layers and to reach constant values of 3.47 ± 0.03 eV and 114 ± 12 amp $cm^{-2}$ $deg^{-2}$, respectively, for deposits 15-200 atom layers deep. Qualitative measurements of the ionization potential of uranium by means of surface ionization showed the positive ion current to increase with increasing temperature indicating the ionization potential to be greater than 4.53 eV. The magnitude of the positive ion currents suggested an ionization potential of 4.5-5.0 V.

537.533 : 621.385.032.213.13 : 621.317.332.1

3787 NEW METHODS FOR THE MEASUREMENT OF CATHODE INTERFACE IMPEDANCE. H.B.Frost.
I.R.E. Trans Electron Devices, Vol. ED-6, No. 3, 315-21 (July, 1959).

Two improved methods for the measurement of cathode interface impedance were developed, and their limitations are analysed. One of these, the complementary network method, is an improvement of a technique disclosed at the 1952 I.R.E. National Convention. The other, the shunt admittance bridge, has not been described previously. Both methods allow the measurement of impedance with both small resistance and short time constant, well below the limit, 50 ohms at 0.1 µsec, of most present equipments. With the development of improved cathode alloys, the measurement of interface impedances having short time constants and low resistances has become important to control this parameter in manufacture and to obtain further improvement. For the complementary-network bridge, the theoretical analysis shows the extreme importance of minimizing stray inductance in the complementary network. When corrections are applied, the complementary-network bridge has good accuracy, with less than one-ohm error at 10 ohms and 0.05 µsec and lower relative errors for higher resistances. The shunt admittance bridge is most satisfactory when tubes with transconductances greater than $10^4$ µmho are to be measured. An impedance transformation is used which allows much easier physical realization of the measurement network than in other interface measurement methods. For tubes with transconductances greater than $10^4$ µmho, the shunt admittance bridge will provide accurate time constant and resistance data down to 0.02 µsec and 5 ohms.

537.533 : 539.27

3788 PREPARATION OF THE SURFACE OF A THERMIONIC CATHODE PRIOR TO EXAMINATION BY ELECTRON DIFFRACTION. B.Rump.
Brown Boveri Rev., Vol. 45, No. 11-12, 571-5 (Nov.-Dec., 1958).

Electron diffraction was employed to investigate the surface structure of a new thermionic cathode. The surface was prepared for electron diffraction by removing the basic material from the rear by electro-polishing and cathode sputtering. The assessment of the results is described. This method of preparation can also be employed for other methods of surface investigation.

537.533

3789 USE OF THE PHOTOMULTIPLIER FEU-12 IN SCINTILLATION SPECTROMETRY.
Y.A.Nemilov, V.M.Ovchinnikov, A.N.Pisarevsky and E.D.Teterin.
J. nuclear Energy, Vol. 4, No. 3, 358-65 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4, 51 (1956).

The spectral properties and certain other characteristics are given for the FEU-12, a photomultiplier having venetian-blind type dynodes, developed by G.S.Wildgrube and collaborators.

537.533 : 539.1.07

3790 RESOLVING POWER OF SCINTILLATION MULTIPLIERS AND ITS DEPENDENCE ON VARIOUS PARAMETERS.
P.Görlich, A.Krohs, H.J.Pohl, R.Reichel and L.Schmidt.
Z. angew. Phys., Vol. 10, No. 7, 303-9 (July, 1958). In German.

As a result of experimental research on a multiplier of their own design, (see Abstr. 256 of 1958) the authors have established that a suitable choice of parameters essential for measurements of energy can bring about a rise in the resolving power of a focussed scintillation multiplier. Results are discussed of measurements relating to (1) linearity, (2) uniformity of the photo-cathodes, and (3) the resolution of a scintillation counter being defined by the properties of the scintillation crystal. The required extensive experimental setup, especially the single-channel analyser, is described in detail. F.Lachman

537.533 : 539.1.07 : 621.387.464

3791 RESOLVING POWER OF SCINTILLATION MULTIPLIERS AND ITS DEPENDENCE ON VARIOUS PARAMETERS (CORRECTION).
P.Görlich, A.Krohs, H.J.Pohl, R.Reichel and L.Schmidt.
Z. angew. Phys., Vol. 10, No. 12, 576 (Dec., 1958). In German.

Owing to the abscissa [Fig. 1 in the original paper (see preceding abstract)] having been shifted by 75 keV instead of a 5.7 keV shift of the ordinate, a considerable error was introduced. Nine $\gamma$ lines used for calibration are listed. F.Lachman

537.533 : 537.32

THERMOELECTRIC COOLING OF PHOTOMULTIPLIERS.
See Abstr. 3731

537.533

3792 SECONDARY ELECTRON EMISSION OF NaCl FILMS.
M.V.Gomoyunova.
Fiz. tverdogo Tela, Vol. 1, No. 2, 315-28 (Feb., 1959). In Russian.

Vacuum-deposited NaCl films were used. Their thicknesses were such that the secondary electron emission coefficient $\sigma$ (measured using single pulses) was independent of the film thickness. It was found that the magnitude of $\sigma$, the form of $\sigma = f(U_p)$, where $U_p$ is the primary electron energy, and the change of $\sigma$ under the action of current pulses, all depended strongly on the conditions of preparation of the film, e.g. the substrate temperature and the subsequent thermal treatment. The value of $\sigma$ of NaCl films at a given $U_p$ could be either higher or lower than $\sigma$ of NaCl monocrystals; the values recorded for films varied between 1 and 18 at $U_p$ = 200-3500 eV. A.Tybulewicz

537.533

3793 REFLECTION OF ELECTRONS AND SECONDARY ELECTRON EMISSION BY NaCl FILMS.
M.V.Gomoyunova.
Fiz. tverdogo Tela, Vol. 1, No. 2, 329-39 (Feb., 1959). In Russian.

Secondary electrons are divided into (a) slow electrons, which are truly secondary (emission coefficient $\delta$), and (b) fast electrons, which are elastically or inelastically reflected primaries (reflection coefficient $\eta$). The total emission is the sum of both effects, i.e. the secondary electron emission coefficient is given by $\sigma = \delta + \eta$. In polycrystalline films, the slow secondaries were found to be emitted from depths $\lambda$ which rose with the primary electron energies $U_p$ up to about 600 eV. Above $U_p$ = 600 eV, the slow secondaries were emitted from depths which were independent of $U_p$ and lay between $\lambda$ = 500 and $\lambda$ = 700 A. The reflected electrons came from depths d which increased with $U_p$: 100 A at $U_p = 200$ eV, 2000 A at $U_p = 3500$ eV. It was the depth of re-emission of the reflected primaries (d) that determined the value of the total secondary electron emission coefficient $\sigma$. The value of $\eta$, like that of $\sigma$, was found to depend on the conditions under which the films were prepared.

A.Tybulewicz

537.533

3794 AN OSCILLOGRAPHIC INVESTIGATION OF THE SECONDARY EMISSION OF DIELECTRIC FILMS.
V.M.Lovtsov and A.S.Smirnov.
Radiotekhnika i Elektronika, Vol. 4, No. 9, 1527-33 (Sept., 1959). In Russian.

Briefly describes the double modulation method [Dokl. Akad. Nauk SSSR, Vol. 1, 12 (1953); Zh. eksper. teor. Fiz., Vol. 27, 87 (1954)], whereby the V-A characteristics of KCl films on metal are obtained automatically on an oscillograph screen, using a 2 or 3 electrode system in a device which is described and illustrated schematically. Oscillographs illustrate how the ionic-electronic emission increases to a maximum with a film thickness of $9 \times 10^{-7}$ cm; the effects of target temperature and $K^+$ ion primary beam density on the V-A characteristics are also studied. The velocity spectrum of the true secondary electrons is considered and some important features are pointed out regarding the conditions for electrostatic emission.

D.E.Brown

537.533 : 621.363.2.032.35

3795 THE ROLE OF SPACE-CHARGE CURRENTS IN LIGHT AMPLIFIERS. A.Rose and R.H.Bube.
R.C.A. Rev., Vol.20, No.4, 648-57 (Dec., 1959).

The light-gain, the operating input light level and the exposure for single pictures are derived for light amplifiers of the sandwich type using adjacent layers of photoconductor and electroluminescent material. A key parameter in these relations is the voltage $V_m$ at which space-charge current flow is initiated in the photoconductor. Also involved is a factor M which measures the ratio of recombination centres to traps, both evaluated near the Fermi level. Present photoconductors should permit : (a) light-gains of over 100-fold to be achieved at television frame rates; (b) operation at television frame rates with input light intensities as low as $10^{-1}$ lm/ft$^2$; and (c) exposures for single pictures approaching photographic speeds. Improved performance depends strongly on attaining higher values of M photoconductors.

537.533 : 539.2 : 537.2 : 621.385.032.213.13

3796 NON-STATIONARY PROCESSES IN THE ALUNDUM [FUSED ALUMINA] COATING OF RADIO-VALVE HEATERS AND THEIR ORIGIN. Yu.K.Shalabutov.
Fiz. tverdogo Tela, Vol. 1, No. 2, 296-306 (Feb., 1959). In Russian.

The dynamic V—I characteristics of leakage currents between cathodes and Alundum-coated heaters in radio valves were found to be different from the static characteristics : the dynamic currents were higher and hysteretic loops were observed in the dynamic characteristics. These effects are shown to be due to the formation of space charge by positive ions (high-voltage polarization) in the Alundum coating. These ions are due to defects and impurities in Alundum; the latter may be introduced in the manufacture or in the operation, of the valves.

A.Tybulewicz

537.533 : 621.317.75

3797 SIMPLE, HIGH-SWEEP-SPEED, SINGLE STROKE OSCILLOSCOPE. W.P.Baker.
J. sci. Instrum., Vol. 36, No. 1, 30-1 (Jan., 1959).

A considerable simplification of a high-sweep-speed single stroke oscilloscope is shown to result from the application of the accelerating voltage to the tube in the form of a long-tailed pulse. Apart from the power pack the oscilloscope does not incorporate any thermionic valves.

537.533

3798 TWO ALTERNATIVE DEFINITIONS OF SMALL SIGNAL R.F. POWER OF ELECTRON BEAMS. E.L.Chu.
J. appl. Phys., Vol. 30, No. 10, 1617-18 (Oct., 1959).

If a d.c. electron beam is perturbed, the change in beam power may be expressed either in terms of the change that occurs in a given volume element (Eulerian formulation) or of the change that occurs in a given group of electrons (Lagrangian formulation). The formalism for the perturbation up to any order is presented, and it is shown that the two expressions give the same result for the small-signal case.

B.Meltzer

537.533

3799 COMMENTS ON KLÜVER'S PAPER ENTITLED "SMALL SIGNAL POWER CONSERVATION THEOREM FOR IRROTATIONAL ELECTRON BEAMS". E.L.Chu.
J. appl. Phys., Vol. 30, No. 10, 1618-19 (Oct., 1959).

Examines the postulate often made, e.g. by Klüver (Abstr. 8028 of 1958) and Haus and Bobroff (Abstr. 3173 of 1958), of a surface current on the boundary of an electron beam. By the use of the perturbation formalism of the preceding abstract it is shown that a surface dipole layer must additionally be postulated.

B.Meltzer

537.533 : 621.385.632

3800 ELECTRON BEAMS IN AXIALLY-SYMMETRIC CROSSED FIELDS. J.A.Bradshaw.
I. R. E. Trans Electron Devices, Vol. ED-6, No. 3, 257-61 (July, 1959).

M-type travelling-wave tubes use electron beams that drift in crossed electric and magnetic fields. One such tube, the axiotron, [Abstr. 1456 B of 1951; C.R.Acad. Sci. Paris, Vol. 321, 1132-4 (Nov. 20, 1950)], used a hollow beam drifting parallel to the tube axis in a radial electric field crossed by an azimuthal magnetic field. The addition of an axial magnetic field to the azimuthal one adds another degree of complication and flexibility to the beam equations, yet maintains their symmetry about the tube axis. It gives, in effect, a helical magnetic field crossed by a radial electric field. The behaviour of hollow electron beams drifting in laminar flow through fields of the latter configuration is examined. A stability index for electron paths and four fairly general types of beam is defined. The stability index and the distribution of space charge obtainable in each type as functions of the amplitudes and directions of the fields and drift velocities may then be determined. In general the density tends to be greatest at the inner beam radius, but it is possible to approach uniform density in stable beams. This report does not consider beam launching nor the "gun" problem; nor does it consider over-all beam instabilities such as scalloping.

537.533 : 621.385.6

3801 A LOW POTENTIAL COLLECTOR EMPLOYING AN ASYMMETRICAL ELECTRODE IN AN AXIALLY-SYMMETRIC MAGNETIC FIELD. D.A.Dunn, W.R.Luebke and G.Wada.
I.R.E. Trans Electron. Devices, Vol. ED-6, No. 3, 294-6 (July, 1959).

A collector for a beam-type tube with an axial magnetic focusing field can be made to operate at a potential near cathode potential without returning secondary electrons, if the beam is deflected and caused to pass an asymmetrical electrode properly positioned in the axially symmetric magnetic focusing field. Collection takes place in a region of radial electric field. Experimental results on such a device indicate successful operation, provided the velocity spread in the beam is not too large.

537.533

3802 NECESSARY AND SUFFICIENT TRAJECTORY CONDITIONS FOR DENSE ELECTRON BEAMS.
W.M.Mueller.
J. Electronics and Control, Vol. 6, No. 6, 499-507 (June, 1959).

Derives a general, somewhat complicated, condition on the metric of an orthogonal coordinate system for one set of its coordinate surfaces to be the action surfaces of an electrostatic, non-relativistic beam. The condition is stated to be necessary and sufficient, but the latter only is proved. It is tested on eleven separable coordinate systems.

B.Meltzer

537.533 : 621.385.832 : 621.397.331.2

3803 ELECTROSTATIC OPTICS FOR CAMERA TUBES.
R.W.Redington, G.A.Saum and P.J.Van Heerden.
I.R.E. Trans Electron Devices, Vol. ED-6, No. 3, 297-9 (July, 1959).

Two versions of an electrostatic focusing and deflection system suitable for camera tube applications are described. Focusing properties, resolution and aberrations are discussed.

537.533

3804 THE SPHERICAL ABERRATION OF ELECTROSTATIC LENSES OF REVOLUTION FOR BEAMS OF LARGE APERTURE. METHODS OF MEASUREMENT.
A.Septier and M.Ruytoor.
C. R. Acad. Sci. (Paris), Vol. 249, No.21, 2175-7 (Nov.23, 1959). In French.

Large lenses are used in a simple optical bench wherein the semi-angular aperture of the beam can be varied from $0^\circ$ to $15^\circ$.

For each lens potential, photographic recordings of the image are made in two known positions, so enabling the constant of spherical aberration to be calculated. R.Reed

537.533

3805 A CERTAIN PROPERTY OF THE IMAGE CURVATURE IN SHORT ELECTRON-OPTICAL LENSES. O.I.Seman.
Optika i Spektrosk., Vol. 7, No. 1, 113-15 (July, 1959). In Russian.

The author shows that the meridional curvature of the image formed by "short" electrostatic lenses can be corrected, at certain magnifications, by means of diaphragms between the second focus and the object, or between the second focus and the image.

A.Tybulewicz

537.533

3806 AN OPTICAL SYSTEM OF ROTATIONAL SYMMETRY FORMED BY COMBINING TWO DOUBLETS OF STRONG CONVERGENCE. D.Dhuicq and A.Septier.
C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2031-3 (Nov. 16, 1959). In French.

Two crossed-quadrupole lenses can be made to act as a single strong lens of rotational symmetry but the focal points are inaccessible. By combining two such systems it might be hoped that the focal point could be made to fall outside the lens system without loss of strength. Such a lens could be used as an objective in an electron microscope. Unfortunately, under the special conditions chosen for this calculation it turns out that an external focus is not possible. A.E.I. Research Laboratory

537.533

3807 ELECTRON MICROSCOPE LENS FOR THE INVESTIGATION OF SPECIMENS IN A GASEOUS ATMOSPHERE.
I.G.Stoyanova and P.V.Zaitsev.
Pribory i Tekh. Eksper., 1959, No. 3, 138-9 (May-June). In Russian.

Describes the construction of a magnetic objective lens for the electron microscope into which a vacuum-tight cell containing the specimen can be placed. Thin windows allow the passage of electrons without undue loss of energy. A resolution of about 80 A has been obtained on a film of colloidal gold at atmospheric pressure.

T.Mulvey

537.533

3808 USE OF A PLATINUM FILAMENT IN THE ELECTRON MICROSCOPE. F.W.Bishop.
Rev. sci. Instrum., Vol. 31, No. 2, 124 (Feb., 1960).

A platinum filament covered with a mixture of oxides has been used to replace the tungsten filament in the R.C.A. model EMU-2 electron microscope. This unit originally was used on an Akashi electron microscope. Since the filament operates at a low temperature, evaporation of the filament itself is very slow. The electron source is very small. The drift of illumination is small and the field of illumination is quite uniform.

537.533

3809 ELECTRON-OPTICAL DESIGN OF AN X-RAY MICRO-ANALYSER. T.Mulvey.
J. sci. Instrum., Vol. 36, No. 8, 350-5 (Aug., 1959).

A system is described that has proved suitable for a practical X-ray micro-analyser using magnetic lenses of axial symmetry. Brief reference is made to possible future developments such as the introduction of corrected lenses.

## ION EMISSION . ION BEAMS

537.534

3810 HEAVY IONS FROM A RADIO-FREQUENCY PROTON SOURCE. F.Grønlund and W.J.Moore.
J. chem. Phys, Vol. 31, No. 4, 1132-3 (Oct., 1959).

The presence of heavy ions with m/e = 19, tentatively identified as $H_3O^+$ in the output of a radiofrequency ion source containing purified hydrogen, is reported. The initial yield of this ion, after ion source cleaning, was 8 μA compared with 20 μA of $H^+$. After 8 hours running, it had decreased to a constant value of 1 μA. The presence of another ion beam with m/e 36 ± 1 was also detected, but the yield of this fell to zero after 2-3 hours. These results suggest that there may be an appreciable concentration of heavy neutral molecules in the beam which may contribute strongly to the high sputtering yield of neutral beams previously reported and attributed to light neutrals (Abstr.1542 of 1959). R.E.Meads

537.534

3811 PARTICLE OPTICS OF RAY SYSTEMS WITH CURVED AXES. H.Dormont.
Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 11-12, 1341-87 (Nov.-Dec., 1959). In French.

The particle optics of systems involving curved axes is reviewed fundamentally. Equations for the motion of particles are derived and the conditions for image formation obtained. The nature and extent of aberrations is discussed. Particular attention is paid to chromatic effects and isochronism in klystrons; space charge is also extensively discussed. A few special applications are worked out.

A.E.I.Research Laboratory

537.534 : 539.18

3812 ISOTOPIC ANALYSIS OF LITHIUM BY MASS SPECTROMETRY.
P.G.Bentley, J.Bishop, D.F.Davidson and P.B.F.Evans.
J. sci. Instrum., Vol. 36, No. 1, 32-4 (Jan., 1959).

A mass spectrometer has been built specially for the isotopic analysis of lithium. Conventional solid-source techniques are used, but the tube unit and electronic system have several novel features. Provision is made for pumping down two ion sources at once by having three arms in the mass spectrometer tube instead of the usual two; one arm takes the collector and the other two take ion sources, so that either source arm and the collector form a 60° sector mass spectrometer. Each source arm is fitted with a vacuum lock to reduce pumping times. Measurements of the isotope ratio are made semi-automatically once ion beams are obtained. By scanning the magnetic field, each ion beam is brought alternately on to the collector, where it is amplified and "remembered" as a voltage on a capacitor. The amplifier sensitivity is adjusted for one beam until the two voltages are equal, and the isotope ratio is read directly as the ratio of the amplifier sensitivities for the two ion beams. Fractionation effects in the ion source are described. The precision of measurement of the isotope ratio is 0.7% at the 95% confidence level, and the absolute accuracy of these measurements is thought to be better than 2%. The instrument is reliable and simple to use, and analyses can be made at the continuous rate of one every twenty minutes.

537.534

3813 DETECTION OF ION BEAMS BY ELECTRON MULTIPLIERS IN MASS SPECTROMETRY AND NUCLEAR PHYSICS. A.I.Akishin.
Uspekhi. fiz. Nauk, Vol. 66, No. 2, 331-46 (Oct., 1958). English translation in: Soviet Physics—Uspekhi (New York), Vol. 66 (1), No. 1, 113-23 (Sept.-Oct., 1958).

The article reviews the performance of Be-Cu electron multipliers as detectors in mass spectrometry. Figures are given for conversion efficiency and gain stability for ions of different energy. An extensive bibliography is appended.

A.E.I. Research Laboratory

537.534 : 539.18

SMALL-ANGLE SCATTERING IN COLLISIONS BETWEEN NEUTRAL ATOMS. See Abstr. 2723

537.534

3814 THE ENERGY LOSS OF HELIUM AND NITROGEN IONS IN METALS. D.I.Porat and K.Ramavataram.
Proc. Roy. Soc. A, Vol. 252, 394-410 (Sept. 29, 1959).

The rate of energy loss of helium and nitrogen ions passing through thin aluminium, nickel, silver and gold foils was measured. Results are presented for helium ions in the energy interval of 0.4 to 1.0 MeV and for nitrogen ions up to 1.8 MeV. The relative accuracy of the results is about 1% and the absolute accuracy better than 5%. Relative mass stopping powers for helium ions at 3.72 and 4.33 MeV are also quoted. Results are compared with earlier work, where available, and agreement is found to be within the experimental errors.

537.534

3815 THE CATHODIC SPUTTERING OF SILVER.
G.J.Ogilvie and M.J.Ridge.
J. Phys. Chem. Solids, Vol. 10, No. 2-3, 217-21 (July, 1959).

Single and polycrystalline specimens of silver have been sputtered at pressures in the ranges 10-50 × $10^{-3}$ and

$-1.0 \times 10^{-3}$ mm Hg. It has been shown that sputtering with
ium, argon and xenon ions does not roughen the surface, but
ds to make it smooth. Mercury and oxygen produce facets. A
ycrystalline specimen sputtered with inert-gas ions develops
ps at the boundaries between adjacent crystals. This is shown to
due to the sputtering rate being dependent on the orientation
the exposed crystal face.

## PARTICLE ACCELERATORS

537.54

### 3816 RELATIVE ENERGY CALIBRATION OF ELECTRON ACCELERATORS. E.Matsukawa and B.N.C.Agu.

sci. Instrum., Vol. 36, No. 7, 316-17 (July, 1959).

Measurements of electron transmission through metallic foils
ggest that accurate relative calibration of an electron accelerator
y be possible using foil transmission data. Standardization of
asurement at a predetermined very small transmission ratio for
series of beryllium-foil thicknesses would lead to calibration data
arly independent of apparatus. A circuit for the measurement of
ectron-beam current ratios is described. This circuit is particu-
rly suited to the measurement of the very small transmissions
commended.

537.54 : 538.56

FIELDS IN SLANTED-GAP EXCITED RECTANGULAR DUCTS.
e Abstr. 2450

537.54 : 537.7 : 621.317.32

HIGH-PRECISION VOLTAGE MEASUREMENT ON THE
ERMINAL OF A VAN DE GRAAFF ACCELERATOR. See
bstr. 2295

537.54

### 3817 BOLTZMANN EQUATION FOR AN ELECTRON GUIDE FIELD ACCELERATOR. I. QUASI-STATIONARY OLUTIONS FOR AN ELECTRON BEAM. J.B.Ehrman.

hys. of Fluids, Vol. 3, No. 1, 121-8 (Jan.-Feb., 1960).

A simplified model for dePackh's version [Third International
onference on Ionization Phenomena in Gases (Italian Physical
ociety, Venice, Italy, 1957), p. 236.] of an electron guide field
ccelerator is set up by substituting for the actual external quad-
upole or solenoidal focusing magnetic field an azimuthally sym-
etric focusing field and by replacing the actual toroidal geometry
y a cylindrical geometry with periodic boundary conditions. The
oltzmann equation for an electron beam in this system is studied,
nd a set of solutions is obtained which contain just enough para-
eters to represent the quasi-stationary behaviour of the beam
ealistically. The values of these parameters are related to the
itial conditions of the beam by the adiabatic invariance of linear
harge density and of the radial and azimuthal action integrals in
he absence of collisions and radiation. Thus, the quasi-stationary
evelopment of the beam in time is determined without an explicit
ime dependence in the Boltzmann equation. While the electron
nergy is being increased by a betatron field, the beam passes from
condition in which its electrons are in almost neutral equilibrium
ith respect to displacement from the axis (low temperature or "$\frac{3}{2}$"
egime) to a condition in which each electron is hardly affected by
he other electrons (high temperature or betatron or "$\frac{1}{2}$" regime),
s predicted by dePackh. If the beam is initially isothermal, the
emperature becomes a monotonic decreasing function of distance
rom the axis in the course of electron energy increase.

537.54

### 3818 AN ACCELERATOR WITH A HELICAL FIELD. J.Teichman.

Czech. J. Phys., Vol. 9, No. 2, 262-3(1959).

The results are given of a theoretical study of a continuously operating cyclotron, designed to work in the ultra-relativistic region The guiding magnetic field is continuous and grows exponentially with the coordinate along the symmetry axis. The field is modulated by inhomogeneities which describe a helix. In this way it is possible to arrange for the constancy of the circular frequency of the particles and for the stability of their betatron oscillations. E.J.Squires

537.54

### 3819 ELECTRON BEAM IN BETATRON. M.Seidl.

Czech. J. Phys., Vol. 9, No. 5, 652-65 (1959). In Russian.

The shape of the beam of charged particles in an annular accelerator is derived using a hydrodynamic approximation. Two cases are studied: an equilibrium beam, which is an idealized model of a beam of captured particles, and a non-equilibrium beam, which is formed of injected particles. The experiments carried out on an electron beam in a betatron agree with theory. The term capture efficiency of electrons $\eta = Q/Q_t$ is introduced, where Q is the captured charge and $Q_t$ the maximum charge which can be maintained by the stabilizing forces of a magnetic field. It is shown that in existing betatrons the efficiency $\eta$ attains only a few percent.

537.54

### 3820 USE OF ELECTRIC-CURRENT SHIMS IN THE CYCLOTRON.

J.H.Fremlin, W.Hardy and H.R.Shaylor.

J. sci. Instrum., Vol. 36, No. 9, 390-2 (Sept., 1959).

The design and the method of construction of electric-current shims for the Birmingham cyclotron are described. Measurements are given showing the effects of these on magnetic-field distribution. Representative beam-current measurements are given which show that with shim-currents up to 500 A, the method was successful in making possible the acceleration of $H^+$ or $(He^3)^{++}$ ions with about the same efficiency as the $D^+$ ions for which the permanent steel shims were adjusted.

537.54 : 539.17

### 3821 FOCUSING AND ANALYSIS OF THE BEAM OF THE CYCLOTRON AT THE COLLÈGE DE FRANCE. APPLICATION OF THE ANALYSED BEAM OF α-PARTICLES FOR THE COULOMB EXCITATION OF HEAVY NUCLEI. M.Vivargent.

Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 9-10, 1047-109 (Sept.-Oct., 1959). In French.

A detailed description of the quadrupole lenses and analysing magnets used to focus the external beam of the cyclotron to produce beams of deuterons and α-particles (11.3 ± 0.3 MeV) for experimental purposes, followed by an account of the experimental results obtained on the Coulomb excitation of the nuclei of tantalum, gold ($Au^{197}$) platinum, and lead, by α-particles. S.J.Goldsack

537.54

### 3822 BETATRON ENERGY CALIBRATION BY MAGNETIC FIELD MEASUREMENT. A.S.Penfold and E.L.Garwin.

Rev. sci. Instrum., Vol. 31, No. 2, 155-63 (Feb., 1960).

Determination and control of the operating energy of a 100 MeV betatron are discussed. The system is based on a determination of the magnetic field at the tip of the X-ray target at the instant of X-ray production. It is believed than an accuracy of 0.25% was obtained.

537.54 : 621.384.612.12

### 3823 HIGH ENERGY, HIGH CURRENT SYNCHROTRON INJECTOR. G.R.Davies and P R.Chagnon.

J. sci. Instrum., Vol. 36, No. 7, 306-8 (July, 1959).

The construction and testing of a pulsed 450 keV injector for an electron synchrotron are described. High voltage is obtained with a spark gap and pulse transformer. The electron-optical system consists of a series of electrodes connected to a voltage divider programmed so as to approximate the field in a space-charge-limited plane diode. Quadrupole lenses are used to optimize the shape of the beam spot and to counteract space-charge spreading. Details are given of the dependence of beam current on energy and on filament power.

## MAGNETISM

*(The magnetic properties of solids are included under Solid-State Physics; similarly for Liquid State and Gaseous State)*

538

### 3824 AN OPTICAL MAGNETOSTRICTION MEASURING DEVICE. R.Ochsenfeld.

Z. InstrumKde, Vol. 67, No. 9, 241-2 (Sept., 1959). In German.

Developed for measurements on small specimens. The variation of the specimen's length changes the distance between a movable mirror and a fixed glass plate, thereby displacing the Haidinger rings. The shift of the rings is proportional to the change of the length.

538 : 621.317.44

### 3825 SENSITIVE RECORDING MAGNETIC FLUXMETER.

P.Lerond and A.Thulin.

J. sci. Instrum., Vol. 36, No. 9, 388-9 (Sept., 1959).

The fluxmeter described uses a taut-suspension galvanometer, the torque of which is compensated by positive feedback. This latter is furnished by a servo-operated potentiometer, the wiper of which follows the motion of the galvanometer light spot. The device is an adaptation of a commercially available recorder and permits recording of flux-variations as low as 100 Maxwell-turns per second.

538 : 621.317.44

### 3826 THE MAGNETIC TENSIOMETER AND ITS REALIZATION.

R.Bellasio.

Elettrotecnica, Vol. 46, No. 12, 846-52 (Dec. 10, 1959). In Italian.

The term magnetic tensiometer is applied to a device for measuring the magnetic potential between two points in a magnetic field. The instrument comprises a solenoid, long compared to its diameter and a current meter, usually a ballistic galvanometer. Expressions are derived, in terms of the galvanometer constants, for the optimum resistance and turns of the solenoid. It is also shown that, the resistance having been determined, the number of turns may be varied considerably without appreciably affecting the tensiometric constant. W.G.Stripp

538 : 621.317.44

### 3827 TIM; A BRUSHLESS GENERATING MAGNETOMETER.

C.W.McCutchen.

J. sci. Instrum., Vol. 36, No. 11, 471-4 (Nov., 1959).

TIM (the turbo-inductor magnetometer) is an air-driven generating magnetometer which uses inductive output to avoid brushes and slip rings. The resulting mechanical simplicity allows this magnetometer to be made very small while the high rotational speed, which is possible because there are no brushes, makes the magnetometer quite sensitive. It is most suitable for measuring static or very nearly static magnetic fields. The output is an audiofrequency signal, and the accuracy depends chiefly on how accurately the amplitude and frequency of that signal are measured.

538 : 621.317.44

### 3828 STABILIZED TORQUE MAGNETOMETER.

W.F.Archenhold, A.C.Brown and J.E.Thompson.

J. sci. Instrum., Vol. 36, No. 12, 505-6 (Dec., 1959).

An improved torque magnetometer has been developed which enables measurements of torque to be made with high precision and under conditions of complete stability. The specimen torque is balanced by means of an electric current passing through the coil of a moving coil meter movement, which replaces the normal torsion head and wire. A small permanent magnet is mounted on an extended movement pointer, so that one pole is capable of restricted motion in the field of two opposing current carrying coils, which provide the necessary stability. The principle employed for producing stability is capable of application to fields other than magnetism.

538 : 537.7

### MECHANICAL MODULATOR FOR MAGNETIC FIELDS.

See Abstr. 3708

538 : 550.3

### 3829 SPINNER-MAGNETOMETER FOR THERMAL DEMAGNETIZATION EXPERIMENTS ON ROCKS.

F.D.Stacey.

J. sci. Instrum., Vol. 36, No. 8, 355-9 (Aug., 1959).

A spinner-magnetometer was built to obtain continuous records of magnitudes and directions of the remanent magnetic moments of rock specimens while they are heated to temperatures up to $800^\circ$C. The specimens are rotated at 78 c/s in a non-inductive electric furnace through which a flow of inert gas is maintained, and the voltages which are produced in a large detecting coil outside the furnace are amplified and measured electronically.

538 : 621.318.1 : 621.374.32

### 3830 MILLIMICROSECOND MAGNETIC SWITCHING AND STORAGE ELEMENT.

D.A.Meier.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 45S-46S (April, 1959).

A magnetic rod suitable for performing the logical switching and storage functions required in a digital computer has been developed. The magnetic element consists of a silver coated glass rod upon which is electroplated a Fe–Ni alloy several thousand angstroms thick. A single element for a coincident-current memory requiring two inputs, an inhibit winding, and a sense winding would consist of four separate single layer concentric solenoids wound over the magnetic rod. Memory matrices, each consisting of many solenoid can be stacked and simultaneously threaded with the rod. The switching speed of the element operating in a coincident-current mode is approximately 70 m$\mu$sec. The output voltage generated across a ten-turn sense winding is 200 to 500 mV depending upon the alloy thickness. The rod is also suitable as a multi-input logical switch. Separate inhibiting windings wound over the rod perform the NOR function of its input literals. A total of thirty separate inhibiting windings have been demonstrated in the laboratory. Satisfactory operation in the 2 to 5 Mc/s range using transistors in conjunction with the rod has been shown to be practical. Continuous plating and testing in conjunction with automatic machine winding techniques make the rod appear economically attractive in digital computer applications.

538 : 621.318.1 : 621.374.3

### 3831 COINCIDENT-CURRENT NONDESTRUCTIVE READOUT FROM THIN MAGNETIC FILMS.

L.J.Oakland and T.D.Rossing.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 54S-55S (April, 1959).

By using cores which consist of two-vacuum-deposited ferromagnetic films it is possible to build memory arrays from which data can be read out nondestructively by use of coincident-current selection. It is thus possible to eliminate the external selection matrices commonly associated with nondestructive readout memori This system promises to be inexpensive, reliable, and fast, especially in a memory in which read operations occur more frequently than write operations. Three different devices are described which fulfil the criterion of coincident-current nondestructive readout. Good signal-to-noise has been achieved with each of these.

538 : 538.56 : 621.372.832.

### 3832 Y CIRCULATOR.

H.N.Chait and T.R.Curry.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 152S-153S (April, 195

The field distribution in a rectangular wave guide containing a magnetized ferrite can be asymmetrical even though the physical configuration is symmetrical. By properly choosing the ferrite, its shape, and location, it is possible to concentrate the energy on one side of the wave guide. Reversing the field or changing the directio of propagation will cause the energy to concentrate on the other side of the wave guide. This phenomenon has been utilized to construct a new type of circulator. A ferrite post has been placed at the junction of three wave guides intersecting at $120^\circ$. The d.c. field is applied transverse to the broad side of the wave guide. Circulator action can be obtained by using a ferrite rod of the correct size and applying a d.c. field of the proper magnitude. Similar results have been obtained by using single and double slab configurations as well as with wedges. A wave guide switch can be obtained by reversing the direction of the applied field. Results to date indicate that it is possible to build this Y-type circulator with a loss less than 0.5 dB and isolations and reflections of greater than 20 dB over a 300 Mc/s band at X band.

538

### 3833 MICROWAVE MAGNETIC FIELD NEAR A CONDUCTIN PERTURBATION.

D.S.Rodbell.

J. appl. Phys., Vol. 30, No. 11, 1845-6 (Nov., 1959).

The intensity of magnetic resonance absorption has been used to examine the microwave magnetic field strength near a conductor that perturbs the microwave electric field of a resonant cavity. It is shown that locally intense microwave magnetic field strengths may be obtained, with a relatively small amount of applied power, by the use of such perturbations. A scheme of the kind proposed would seem attractive in applications using samples of small volume as in the case of magnetic solids; and where microwave power is limited. S.A.Ahern

## ELECTROMAGNETISM

## MAGNETOHYDRODYNAMICS

538.3

### 3834 THE USE OF DE BROGLIE'S ELECTROMAGNETIC ENERGY–MOMENTUM TENSOR IN CLASSICAL ELECTROMAGNETISM.

O.Costa de Beauregard.

C.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2285-6 (Nov. 30, 1959). In French.

An expression derived for the couple density for the classical field involves the tensor

$$\tfrac{1}{2}(H^{jk}\partial^i A_k - A_k\partial^i H^{jk}).$$

This tensor is related to the photon spin density. R.A.Newing

538.3

3835 **ELECTROMAGNETISM AS A SECOND-ORDER EFFECT. I. THE DEFINITION OF THE AMPERE.** W.G.V.Rosser.
Contemporary Physics, Vol. 1, No. 2, 134-41 (Dec., 1959).

By considering simple examples from the viewpoint of both classical electromagnetism and the special theory of relativity, it is shown that the magnetic forces between moving charges are of order $v^2/c^2$ times the electric forces between the charges, where v is the velocity of the charges. The relevance of electric forces in the definition of the ampere is discussed.

538.3

3836 **FIELDS OF AN ACCELERATED POINT CHARGE.** B.C.Carlson.
Amer. J. Phys., Vol. 27, No. 9, 669-70 (Dec., 1959).

The relation between the magnetic and the electric fields of an accelerated point charge is derived directly, starting from the Lienard—Wiechert potentials, without first evaluating either of these fields. J.K.Skwirzynski

538.3 : 551.5

3837 **STABILITY OF THE ADIABATIC MOTION OF CHARGED PARTICLES IN THE EARTH'S FIELD.** T.G.Northrop and E.Teller.
Phys. Rev., Vol. 117, No. 1, 215-25 (Jan. 1, 1960).

The motion of charged particles in a magnetic field such as that of the earth or that of a magnetic mirror machine is discussed. It is shown that during the motion and drift of a relativistic particle, not only the magnetic moment, but also a longitudinal invariant and an additional flux invariant are adiabatically conserved. These conservation laws lead to retention of the particles in the field. The derivation of the adiabatic invariants leads to a set of equations of motion which describe the average drift of the particles from one force line to the other, and which also describe the changes that occur in the energies and periods associated with the motion. In the absence of scattering, loss of particles from the magnetic field will be due to the violation of the adiabatic laws.

538.3

3838 **ON THE RADIAL PULSATIONS OF AN INFINITE CYLINDER WITH A MAGNETIC FIELD PARALLEL TO ITS AXIS.** K.P.Chopra and S.P.Talwar.
Proc. Nat. Inst. Sci. India A, Vol. 21, No. 5, 302-13 (Sept. 26, 1955).

The expression for the amplitudes of the radial adiabatic pulsations and consequent magnetic variations of an infinitely conducting, infinite cylinder, subject to a variable axial field, are obtained. The numerical calculations of the characteristic amplitudes are carried out for six different models of the particular case in which the magnetic field is assumed to be proportional to the square root of pressure. Further, the period of pulsation is found to decrease with the magnetic field.

538.3

3839 **ON THE RADIAL ADIABATIC PULSATIONS OF AN INFINITE CYLINDER IN THE PRESENCE OF MAGNETIC FIELD PARALLEL TO ITS AXIS. II.** K.P.Chopra.
Proc. Nat. Inst. Sci. India A, Vol. 21, No. 5, 314-20 (Sept. 26, 1955).

The higher approximations to the characteristic functions and the contributions of other modes are dealt with.

538.3

3840 **A NOTE ON THE OSCILLATIONS OF AN INFINITE CYLINDER SUBJECT TO RADIAL MAGNETIC FIELD.** J.Narain Tandon.
Proc. Nat. Inst. Sci. India A, Vol. 21, No. 6, 394-403 (Nov. 26, 1955).

The oscillation of a cylindrical fluid in the presence of a permanent magnetic field has been considered. The magnetic field has been assumed due to infinite axial line magnetic pole.

538.3

3841 **MAGNETOHYDRODYNAMIC WAVE OF FINITE AMPLITUDE AT MAGNETIC PRANDTL NUMBER 1.** H.Hasimoto.
Phys. of Fluids, Vol. 2, No. 5, 575-6 (Sept.-Oct., 1959).

Under certain conditions the nonlinear terms for the velocity and magnetic field disappear from the hydromagnetic equations, and the equations permit the existence of a solenoidal dissipative wave. The equations also allow steady solutions which describe fields at points in wakes far behind an obstacle. R.A.Newing

538.3 : 537.56

3842 **THE SIMPLEST PROBLEMS INVOLVING SHOCK WAVES WHICH IONIZE GASES IN AN ELECTROMAGNETIC FIELD.** A.G.Kulikovskii and G.A.Lyubimov.
Dokl. Akad. Nauk SSSR, Vol. 129, No. 3, 525-8 (Nov. 21, 1959).
In Russian.

By considering in some detail the shock wave associated with a moving piston, relations are obtained between the speed of the piston, the wave velocity and the difference of densities on either side of the shock front. Results are applied to shock waves propagating about a wedge. R.Eisenschitz

538.3 : 537.56

3843 **EXPERIMENTAL STUDY OF ALFVÉN-WAVE PROPERTIES.** J.M.Wilcox, F.I.Boley and A.W.DeSilva.
Phys. of Fluids, Vol. 3, No. 1, 15-19 (Jan.-Feb., 1960).

Alfvén hydromagnetic waves are propagated through a cylindrical plasma. The wave velocity, attenuation, impedance, and energy transfer are studied. The theoretical equations predict correctly the functional dependence of the velocity and attenuation, and from these quantities accurate measurements of plasma density and temperature can be obtained. A qualitative agreement between theory and experiment is obtained for the hydromagnetic coaxial waveguide impedance, and the energy transferred from an oscillating circuit to the hydromagnetic wave is measured to be 43 ± 10%.

## ELECTROMAGNETIC WAVES AND OSCILLATIONS

538.56 : 517

3844 **THE DISTRIBUTIONS OF ONE VARIABLE: RELATIONS BETWEEN TWO DEFINITIONS, DIFFERENTIATION, INTEGRATION.** M.Bouix.
Ann. Telecomm., Vol. 14, No. 9-10, 236-55 (Sept.-Oct., 1959).
In French.

The study of an electromagnetic field, generated by a harmonic source in the presence of some obstacles, leads directly to some solution of the system of Maxwell's equations and hence of the Helmholtz vectorial differential equation, where the elements of sources and of obstacles are seldom rigorously treated. The author introduces, after Mikusinski and Sikorski, a distribution of a variable, defined as a limit of set of functions and deduces the existence of derivative of such variable. The concept of value of such distribution at a point leads the author to consideration of a distribution as a superposition of a continuous function and an ensemble of Dirac functions and their derivatives. On the other hand, following Schwartz, the author considers a distribution as a linear functional defined in a functional space and hence correlates the two definitions. He shows that whereas the first definition is more fundamental, the second is more suitable for actual calculations. J.K.Skwirzynski

538.56 : 621.373.3

3845 **A NEW MICROWAVE HARMONIC GENERATOR.** K.D.Froome.
Nature (London), Vol. 184, 808 (Sept. 12, 1959).

A very short gap mercury arc possesses a non-linear voltage—current relationship. Microwave power is fed into an arc developed between a fine tungsten wire and a mercury pool cathode and the nonlinearity gives rise to harmonic generation. A few watts of input power at 2.5 Gc/s produced 1 mW at 10 Gc/s and also a strong signal at 30 Gc/s. It thus appears that such arcs may provide useful millimetre wave generators comparable with most sources at present in use. G.D.Sims

538.56 : 538.27 : 539.2

**HARMONIC RESONANCES IN SMALL FERRIMAGNETIC ELLIPSOIDS.** See Abstr. 3120

538.56 : 621.374.44

### 3846 SQUARE-WAVE GENERATOR FOR THE STUDY OF EXPLODING WIRES. T.J.Tucker.

Rev. sci. Instrum., Vol. 31, No. 2, 165-8 (Feb., 1960).

A 100-kV coaxial cable square-wave generator producing a 2000 A, 3-$\mu$sec duration, 6-m$\mu$sec rise time, current pulse has been constructed for the study of exploding wires. Unlike conventional capacitor sources the circuit behaviour is described by algebraic rather than nonlinear differential equations, thus allowing easier and surer interpretation of results. Using coaxial-cable techniques for the entire system also provides m$\mu$sec resolution of current and voltage wave forms. The system features an output timing pulse, occurring 1.5 $\pm$ 0.005 $\mu$sec prior to the beginning of the wire explosion which provides triggering for oscilloscopes and for a 5-m$\mu$sec exposure time Kerr-cell camera. The electrical isolation of the output trigger pulse from the monitored signal also eliminates waveform distortion produced by trigger circuit loading and signal delay.

538.56 : 621.375.9

### 3847 THE OPTIMUM LINE WIDTH FOR THE TRANSITION USED IN A REFLECTION CAVITY MASER AMPLIFIER.

G.J.Troup.

Austral. J. Phys., Vol. 12, No. 3, 218-21 (Sept., 1959).

The line width of the amplifying transition in a reflection cavity maser is shown to have an optimum value, which will give maximum amplification bandwidth at a fixed gain. Difficulties associated with achieving the optimum line width in practice for the paramagnetic maser are briefly discussed.

538.56 : 621.375.9

### 3848 AN INTRODUCTION TO THE THEORY OF SOLID-STATE MASERS WITH PARTICULAR REFERENCE TO THE TRAVELLING WAVE MASER. P.N.Butcher.

Proc. Instn Elect. Engrs, Paper 3220 E, publ. Feb., 1960, 11 pp.
To be republished in Vol. 107 A (1960).

The relevant properties of paramagnetic ions are described and the quantum theory of maser action is outlined qualitatively. A semi-classical treatment is developed which is based on the classical equation of motion of a magnetic dipole. It is used to evaluate the engineering characteristics of a travelling-wave maser which employs the comb type of slow-wave guide.

538.56 : 621.375.9

### 3849 MASER BEHAVIOR: TEMPERATURE AND CONCENTRATION EFFECTS. T.H.Maiman.

J. appl. Phys., Vol. 31, No. 1, 222-3 (Jan., 1960).

A solid-state maser using $Al_2O_3$ : 0.2% $Cr_2O_3$ as the active material has been operated at 77.4° K, with a signal frequency of 9.14 kMc/s and using push-pull pumping at 23.1 kMc/s. Preliminary measurements give a gain-bandwidth product of about 14 Mc/s, and an effective noise temperature of 100° K excluding input losses. The construction of the maser is described. In addition, maser action has been observed at temperatures up to 195° K, using dry ice as the coolant. Preliminary studies to determine the effect of paramagnetic-ion density on maser performance are also reported.
S.A.Ahern

538.56

### 3850 A NUCLEAR MAGNETIC RESONANCE MASER. G.H.Benoit.

Ann Phys. (Paris), Ser. 13, Vol. 4, No. 11-12, 1439-83 (Nov.-Dec., 1959). In French.

A new type of two level maser has been developed, employing an original technique for inverting the populations of the two levels by adiabatic fast passage. The fast passage condition has been studied theoretically using an analogue computer and experimentally, with good agreement. The technique described has been used to obtain maser oscillation at 30 Mc/s, in a magnetic field of 7000 Oe, employing water as the active material; oscillation has also been obtained at 14 Mc/s in a field of 3.3 Oe. The latter maser has been studied in detail. Possible practical applications of a device employing this principle are discussed. S.A.Ahern

538.56 : 621.375.9

### 3851 OPERATION OF A ZERO FIELD X-BAND MASER. J.E.King and R.W.Terhune.

J. appl. Phys., Vol. 30, No. 11, 1844-5 (Nov., 1959).

A maser using 0.1% nominal iron doped $Al_2O_3$ was successfully operated as an amplifier at 12.3 kMc/s, using only a very small magnetic field (120 Oe) for tuning. The pump frequency was 31.8 kMc/s, and the temperature of operation 4.2° K. S.A.Ahern

538.56 : 621.372.633

### 3852 STUDY OF A MICROWAVE FERRIMAGNETIC MULTIPLE SIGNAL CONVERSION PROCESS.

E.N.Skomal and M.A.Medina.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 161S-162S (April, 1959).

A multiple signal conversion process has been observed in ferrimagnetic materials at microwave frequencies. The second harmonic of the input frequency is generated in a magnetized ferrit and caused to mix with the fundamental frequency in the specimen generating the harmonic. A portion of the upper side band power arising from mixing of the fundamental frequency and its second harmonic is constructively added to the third harmonic occurring from harmonic generation. The total output power at the third harmonic is consequently increased.

538.56 : 621.318.435.

### 3853 THE BISTABLE BEHAVIOUR OF THE MAGNETIC TRANSDUCTOR. E.H.Frei, S.Shtrikman and D.Treves.

Brit. J. appl. Phys., Vol. 9, No. 10, 394-5 (Oct., 1958).

It is already well-known that the second harmonic magnetic transductor has instability regions. It has been found experimentally that in each region two modes of output current exist, differing only by the phase which these currents have with respect to the exciting voltage. Under suitable parameters and excitation conditions the transductor will jump from one mode of operation to the other, whenever the exciting current is modulated with a negative pulse. It therefore operates like a bistable element.

538.56

### 3854 PRINCIPLES OF FERRITE REACTANCE AMPLIFICATION. A.G.Fox.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 19S (April, 1959).

No text is given.

538.56 : 621.396.62 : 621.375.9

### 3855 ULTRA-LOW-NOISE MEASUREMENTS USING A HORN REFLECTOR ANTENNA AND A TRAVELING WAVE MASER. R.W.De Grasse, D.C.Hogg, E.A.Ohm and H.E.D.Scovil.

J. appl. Phys., Vol. 30, No. 12, 2013 (Dec., 1959).

A low-noise travelling-wave maser [Abstr. 4205 B of 1959: Bell Syst. tech. J., Vol. 38, No. 2, 305-34 (March, 1959)] and a low-noise horn reflector aerial have been combined to form an ultra low-noise receiving system. Measurements made from Crawford Hill, near Holmdel, New Jersey, U.S.A., on cool clear winter nights at a frequency of 5.65 kMc/s and using a 20 Mc/s bandwidth, gave the following data: T(aerial, waveguide and maser) = 16.0 $\pm$ 0.8° K, T(sky zenith) = 2.5 $\pm$ 0.75° K. The temperature contribution from waveguide circuit and aerial copper loss is calculated to be 3.5 $\pm$ 0.2° K; leaving a value of 12.5 $\pm$ 1° K for the aerial and maser contributions. Further calculations give a value for the maser noise temperature of 10.5 $\pm$ 2° K. S.A.Ahern

538.56 : 539.2 : 538.27 : 621.372.832.8

LOW-LOSS GYROMAGNETIC COUPLING THROUGH SINGLE CRYSTAL GARNETS. See Abstr. 3118

538.56

### 3856 DIFFRACTION OF AN E-POLARIZED PLANE WAVE BY AN IMPERFECTLY CONDUCTING WEDGE.

W.E.Williams.

Proc. Roy. Soc. A, Vol. 252, 376-93 (Sept. 29, 1959).

A new and exact solution is obtained for the diffraction of an E-polarized electromagnetic plane wave by an imperfectly conducting wedge of arbitrary angle. This equation is solved in terms of the double gamma function defined by Barnes (1899). If the wedge angle is equal to $p\pi/2q$ where p and q are relatively prime integers, with p odd, the difference equation is soluble in a simple closed form. The resulting solution for the field component is then comparatively simple. The present theoretical results show very good agreement with experimental results in the shadow region for normal incidence on a 16° wedge.

538.56 : 534.26

### 3857 THE THEORY OF A CLASS OF DIFFRACTION PROBLEMS BY MEANS OF SINGULAR INTEGRAL EQUATIONS. I. K.Westpfahl.

Ann. Phys. (Leipzig), Folge 7, Vol. 4, No. 6-8, 283-351 (1959). In German.

For a class of two dimensional diffraction problems (straight edge, slit, grating) the boundary value problem leads to a singular integral equation of the Cauchy type. The number of equations rees with the number of edges of the screen. In the case of a gle edge the integral equation can be solved by the functional eoretic method of Muskhelishvili which contains the Wiener—Hopf chnique as a special case. The two edge problem is solved ymptotically (for wavelengths small compared with the edge acing) and agrees numerically with the series expansion in terms Mathieu functions. A summary of the mathematical results is ven in an appendix. T.R.Carson

538.56 : 621.391.812.623

### 3858 DIFFRACTION OF ELECTROMAGNETIC WAVES BY SMOOTH OBSTACLES FOR GRAZING ANGLES.

R.Wait and A.M.Conda.

Res. Nat. Bur. Stand., Vol. 63D, No. 2, 181-97 (Sept.-Oct., 1959).

The diffraction of electromagnetic waves by a convex cylindrical rface is considered. Attention is confined primarily to the region ear the light-shadow boundary. The complex-integral represention for the field is utilized to obtain a correction to the Kirchhoff eory. Numerical results are presented which illustrate the influence surface curvature and polarization on the diffraction pattern. ood agreement with the experimental results of Bachynski and eugebauer [see Abstr. 6393B of 1958; Proc. Inst. Radio Engrs, ol. 46, No. 9, 1619-27 (Sept., 1958)] is obtained. The effect of nite conductivity is also considered.

538.56

### 3859 THE SCATTERING OF ELECTROMAGNETIC WAVES BY AN ELECTRON BEAM. H.Wilhelmsson.

uovo Cimento Suppl., Vol. 13, No. 1, 311-17 (1959).

Solutions are found for an infinite plane wave and an infinite ylindrical electron beam, for the two extreme cases of a strong xial magnetic field and zero magnetic field. A.H.Gabriel

538.56 : 621.372.2

### 3860 WAVE PROPAGATION IN A COAXIAL SYSTEM. V.M.Papadopoulos.

uart. appl. Math., Vol. 17, No. 4, 423-36 (Jan., 1960).

A solution is obtained for the problem of the propagation of lectromagnetic waves in a semi-infinite flanged coaxial line with an nfinite centre conductor, in terms of an infinite set of coefficients hich are determined by an infinite set of linear equations. The olution is discussed, in detail, in limiting cases which illustrate roperties both of a thin vertical aerial on a plane perfectly conducting earth, and of a thick aerial fed by a low impedance line. Numercal results are given in these cases. The possibility of a solution or any excitation frequency is also discussed.

538.56 : 621.372.853.2

### 3861 HIGH POWER EFFECTS IN FERRITE SLABS AT X BAND. R.L.Martin.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 159S-160S (April, 1959).

Measurements are reported of the attenuation at 9360 Mc/s of full height ferrite slabs in waveguides as a function of ferrite length up to input powers of 120 kW. The ferrites were transversely magnetized to the field for subsidiary resonance. Above the critical power level for the subsidiary resonance the output power was a linear function of the input power with a slope such that the attenuation of that portion of the input power above the critical power was 7.8 dB/in. The phase change through the ferrite region was essentially independent of power.

538.56 : 621.375.9

### 3862 EXPERIMENTAL STUDY OF THE MODIFIED SEMISTATIC FERRITE AMPLIFIER.

W.L.Whirry and F.B.Wang.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 150S-151S (April, 1959).

A ferromagnetic parametric amplifier operating at 5930 Mc/s is described. The imaginary component of the r.f. susceptibility at the signal frequency is shown to reach a negative maximum for $h_{dc}$ set at ferromagnetic resonance for the difference between pump and signal frequencies. The amplifier is operated both as a regenerative and super-regenerative amplifier using pulsed pump power. As a regenerative amplifier, steady state gains of 20 dB with a band width of 0.5 Mc/s are obtained. As a super-regenerative amplifier, gains of 130 dB with a band width greater than 1.5 Mc/s are obtained. Oscillations reach their limiting value at signal outputs of 150 to 350 W, depending upon ferrite temperature, and exhibit an initial spike. As a high gain super-regenerative amplifier, the input c.w. signal which doubles output average noise power is found to lie between −98 and −103 dBm.

538.56 : 621.391.812.63

### 3863 A DISCUSSION OF IONOSPHERIC DEMODULATION NEAR GYRO FREQUENCY. G.L.Goodwin.

Austral. J. Phys., Vol. 12, No. 2, 157-63 (June, 1959).

Observations made in Adelaide of the ionospheric demodulation of radio waves near gyro frequency at vertical incidence are discussed. The effect occurs in the region of about 90 km, and does not appear to decrease through dawn. An F-layer reflected wave is demodulated by unequal amounts during its two passages through the region. The large magnitude of the effect and its lack of dependence on modulation frequency seem to be inconsistent with the theory of wave interaction.

538.56

### 3864 A STUDY OF "SPREAD-F" IONOSPHERIC ECHOES AT NIGHT AT BRISBANE. IV. RANGE SPREADING.

H.C.Webster.

Austral. J. Phys., Vol. 11, No. 3, 322-37 (Sept., 1958).

For previous work, see Abstr. 6534 (1958). In the course of investigations of satellite echoes from the F region of the ionosphere, it was noted that the F and $E_s$ traces recorded at night, on h't equipment at frequencies well below vertical, are broader than anticipated and tend to change in a characteristic manner as the gain of the receiver is lowered. A quantitative explanation of these phenomena is elaborated, based on the postulate of a "rough" ionosphere. This theory leads to a method whereby, from the swept-gain h't records, estimates of roughness index can be formed. These estimates compare satisfactorily, on a statistical basis, with estimates by other methods. The theory is extended to the case of multiple-hop reflections, and to the satellite traces; general agreement with experiment is found. Evidence is presented that the ionosphere appears rougher when transmitter and receiver are adjacent than when they are widely separated, and a tentative explanation is suggested. From the roughness indices, the relative intensities of Z- and O-mode F echoes for Brisbane are computed and the rare appearance of Z-traces on Brisbane records is satisfactorily explained.

## Radiofrequency Spectroscopy Techniques

538.56

### 3865 A HIGH-RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTROMETER.

H.J Kohler, M.Pettig and G.Scheler.

Exper. Tech. der Phys., Vol. 7, No. 4, 157-61 (1959). In German.

538.56

### 3866 HIGH-RESOLUTION NUCLEAR RESONANCE APPARATUS.

J.B.Leane, R.E.Richards and T.P.Schaefer.

J. sci. Instrum., Vol. 36, No. 5, 220-33 (May, 1959).

A nuclear resonance spectrometer for observing high-resolution spectra of hydrogen and fluorine resonances is described. The spectrometer is of extremely simple design but its stability and resolving power is approximately 1 in $10^8$ when using samples of diameter approximately 5 mm. A thermally-lagged permanent magnet is used to provide the main magnetic field and a simple bridged-T spectrometer is used.

538.56 : 621.317.44

### 3867 NUCLEAR RESONANCE ABSORPTION CIRCUIT. I. SENSITIVITY CONSIDERATIONS. II. PRACTICAL DESIGN. F.N.H.Robinson.

J. sci. Instrum., Vol. 36, No. 12, 481-4, 484-7 (Dec., 1959).

The new circuit described has the sensitivity and flexibility of conventional circuits using a separate oscillator, combined with the convenience and freedom from microphonics of marginal oscillator circuits. In particular, it permits the use of very low levels of oscillation. The principles and theory of the new circuit are given, as well as practical design details.

538.56 : 621.373.4 : 621.316.726

### 3868 FREQUENCY CONTROL OF AN OSCILLATOR BY NUCLEAR MAGNETIC RESONANCE.

R.V.Pound and R.Freeman.

Rev. sci. Instrum., Vol. 31, No. 2, 96-102 (Feb., 1960).

A simple super-regenerative oscillator that produces a coherent signal at the magnetic resonance frequency of a sample in its coil is described in theory and in practice. A c.w. oscillator is phase locked to the super-regenerative oscillator and the signal which results follows variations in the frequency of magnetic resonance, owing to variations of the field, within less than 5 parts in $10^3$; the signal produced is adequately monochromatic and stable enough to be used for magnetic resonance experiments with high resolution. The requirements for time and temperature stabilization of the magnet are very greatly relaxed.

538.56

**3869 PRECISION ZEEMAN MODULATION MICROWAVE SPECTROMETER.** R.W.Zimmerer.

Rev sci. Instrum., Vol. 31, No. 2, 106-11 (Feb., 1960).

A precision Zeeman modulated microwave spectrometer was developed to measure the rotational fine structure of oxygen. The transitions lie between 50 and 65 kMc/s. Direct measurement of th line widths was made at pressures from 20 to 500 $\mu$. The Zeeman components were resolved and compared with the theoretical expectation for the $N_- = 3$ line. Twelve lines were measured to better than 0.01 Mc/s and 11 line breadth parameters were measured to 0.1 Mc/s/mm. Of particular interest is the use of transistor circuits to achieve design simplification and improvement.

## NUCLEAR AND ATOMIC PHYSICS

539

**3870 ACTIVITIES OF THE COORDINATING CENTRE FOR ELECTRONICS OF C.N.R.N. [NATIONAL COMMITTEE FOR NUCLEAR RESEARCH].** B.Rispoli.

Nuovo Cimento Suppl., Vol. 11, No. 3, 405-12 (1959). In Italian.

Owing to the dependence of nuclear physics on advanced techniques, especially electronics, CELE (il Centro di Coordinamento Elettronica) was created to formulate suitable standards, design and develop industrial prototypes of new instruments, and organise their manufacture. Projects at present in hand are described and specifications of instruments now being produced by industry included.
R.D.Smith

539

**3871 THE ACTIVITIES OF THE REGIONAL NUCLEAR RESEARCH COMMITTEE OF SICILY.** M.Santangelo.

Nuovo Cimento Suppl., Vol. 11, No. 3, 413-18 (1959). In Italian.

A review of the nuclear research work in progress at the various universities and the administrative and financial steps taken to foster the future development of pure and applied nuclear research.
R.D.Smith

539

**3872 THE ITALIAN NUCLEAR PROGRAMME AFTER THE SECOND GENEVA CONFERENCE.** F.Ippolito.

Nuovo Cimento Suppl., Vol. 11, No. 3, 419-29 (1959). In Italian.

C.N.R.N. has three main objectives, the training of personnel, the provision of fissile material, and the construction of research reactors. Seven specialist schools are now in operation in the universities. Uranium ores discovered in the Alps will yield 450 tonnes of uranium by the end of 1962, and a pilot plant for the production of metal has been completed. The construction of research centres is the major part of the programme and a table showing the locations of the first seven Italian reactors is given. The economics of nuclear power in Italy is discussed. Two power stations of 150 MW and 200 MW are to be built and a third of 134 MW is planned.
R.D.Smith

## APPARATUS . PARTICLE DETECTORS

539.1.07 : 537.533

**3873 EXO-ELECTRON EMISSION AFTER REVERSAL OF POLARITY IN A COUNTING TUBE.**

H.Pupke and G.Wauschkun.

Exper. Tech. der Phys., Vol. 7, No. 3, 142-4 (1959). In German.

The emission of exo-electrons has been observed after reversal of polarity in a counter with a central tungsten wire and a cylindrical graphite electrode. The effect is attributed to the formation of defect levels in the carbon: when the normal polarity of the tube is reversed, these levels are filled due to electron bombardment by field emission from the tungsten wire, and exo-electron emission results.
C.H.B.Mee

539.1.07

**3874 ON THE DEPENDENCE OF THE OPTIMUM CATHODE THICKNESS [t] ON THE ATOMIC NUMBER [Z] OF THE CATHODE MATERIAL AND THE GAMMA-ENERGY [E] IN A GM-COUNTER TUBE.** H.Gebauer.

Atomkernenergie, Vol. 4, No. 4, 135-8 (April, 1959). In German.

Previous experimental results are summarized, and an empirical expression relating t to Z and E is given which agrees with experiment within ± 20% over the range E = 0.2 to 5.0 MeV.
J.Dutton

539.1.07

**3875 THE INFLUENCE OF THE EMISSION PROPERTIES OF AN ANODE ON THE CHARACTERISTICS OF G.M. COUNTERS.** R.Seidl.

Czech. J. Phys. Vol. 9, No. 4, 517-23 (1959). In Russian.

The mechanism of the production of false pulses is investigated and its influence on the characteristics of counters discussed.

539.1.07

**3876 IMPROVEMENT IN THE PLATEAU OF ARGON—ALCOHOL FILLED G.M. COUNTERS.**

J.Kern and O.Huber.

Helv. phys. Acta, Vol. 32, No. 4, 332-8 (1959). In French.

Describes experiments on counter tubes for a $\beta$-ray spectrometer. Plateau slopes are plotted for various tube parameters, e.g. anode length and guard electrode potentials. A slope of about 0.5% per 100 V plateau length was obtained.
J.D.Craggs

539.1.07

**3877 AUTOMATIC CORRECTION FOR PARALYSIS IN GEIGER COUNTING.** R.Hunt.

J. sci. Instrum., Vol. 36, No. 5, 236-7 (May, 1959).

A simple and inexpensive attachment to a standard probe and scaler unit is described which provides an automatic correction to the scaler reading in radioactive assays using Geiger counters. Over the usual range of operation of these counters, 0 to 16 000 impulses/min, the relative errors in the scaler reading due to paralysis of the counting system are thus reduced to 0.3%.

539.1.07

**3878 LOW BACKGROUND GAS FLOW-COUNTER.**

G.H.Bergold and G.R.Haney.

J. sci. Instrum., Vol. 36, No. 1, 39-44 (Jan., 1959).

A low background flow-counter of comparatively simple construction, operating in the Geiger region, is described. The sample counter is shielded by mercury and surrounded by an anticoincidence ring of eighteen overlapping counters, a top counter, and lead and mercury shields. The counting efficiency with 1 in. diameter steel planchets is 62% for low energy $\beta$ particles such as $C^{14}$; the background is 1.040 ± 0.005 counts/min; and the limit of sensitivity is 0.025 counts/min.

539.1.07

**3879 MAZE COUNTERS WITH BOROSILICATE SHELLS.**

R.W.Kiser.

Rev. sci. Instrum., Vol. 30, No. 11, 1055-6 (Nov., 1959).

Reports successful operation, in both the proportional and Geiger regions, of Maze counters consisting of externally coated, 0.01 in. thick pyrex walls of 1 in. diameter surrounding a 2 mil W wire. Thicker walls may be used at elevated temperatures.
J.Dutton

539.1.07

**3880 PROTON RECOIL PROPORTIONAL COUNTER USED IN SPECTROMETRY OF FAST NEUTRONS.**

P.Marguin and M.A.Moussa.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 1A-9A (March, 1957).
In French.

Description of a proportional counter used for the detection of fast neutrons and the determination of their energies by detecting oil protons produced in a thin hydrogenated radiator. The elec- nic apparatus used with the detector is also described, the results esting the counter with thorium α-particles are given and the oretical pulse-height distribution for monoenergetic neutrons is culated.

539.1.07 : 545

### 3881 PROPORTIONAL COUNTERS IN X-RAY SPECTROCHEMICAL ANALYSIS.

T.Mulvey and A.J.Campbell.
t. J. appl. Phys., Vol. 9, No. 10, 406-10 (Oct., 1958).

Reviews existing theories on the proportional counter in order determine the fundamental limits of resolving power when used as pectrometer for light elements such as magnesium. A survey of perimental results indicates that only a slight further improve- nt in performance is required to enable proportional counters to lyse adjacent elements such as magnesium and aluminium, thus owing one to dispense with an analysing crystal.

539.1.07

### 3882 COMPENSATED IONIZATION CHAMBER SUITABLE FOR THERMAL NEUTRON REACTOR CONTROL.

Duchene, J.Lavergne and J.Weill.
nuclear Energy, Vol. 4, No. 1, 26-32 (Jan., 1957). In French.

A γ-ray compensated $B^{10}$ ionization chamber is described. mphasis has been placed on obtaining an efficient adjustable com- nsation, so as to reduce the γ-ray current 300 to 600-fold. This amber, particularly well suited for reactor control, has a sensiti- ty of $2 \times 10^{-14}$ amperes per neutron $cm^{-2}\ sec^{-1}$. Detection of a inimum flux of 5 neutrons $cm^{-2}\ sec^{-1}$ is possible with a 10% pre- sion in the presence of 0.4 R/hr of γ. Precision of 1% is obtained r a maximum of $5 \times 10^{8}$ neutrons $cm^{-2}\ sec^{-1}$ in a γ field of $4 \times 10^{6}$ hr.

539.1.07

### 3883 IONIZATION CHAMBER RECORDING DEVICE WITH 128 CHANNELS.

N.N.Goryunov.
ribory i Tekh. Eksper., 1959, No. 3, 84-9 (May-June). In Russian.

Gives a full description of the device in question. Each channel as a wide dynamic range enabling pulses differing by 8000 times to e recorded, by photographing the pulses on the screen of an electron eam tube. The electronic commutator section enables 64 pulses to e recorded simultaneously on one screen. Recording accuracy is bout 10%. Detailed circuit diagrams include the ionization cham- er pulse pre-amplifier, the following non-linear amplifier, coinci- ence circuit, memory system (remembering for $10^{-2}$ sec), and nally the electronic commutator cell with associated negative pulse enerator. D.E.Brown

539.1.07

### 3884 MODIFICATION OF THE FARMER ELECTROMETER FOR USE WITH SIEVERT IONIZATION CHAMBERS.

.Thomason.
adiation Research, Vol. 11, No. 2, 253-4 (Aug., 1959).

A brief note describing certain alterations made to the electrodes f a Farmer electrometer. The voltage loss was thus reduced for an 8 hour period from 2.03 to 0.33 V. J.D.Craggs

539.1.07

### 3885 CHARACTERISTICS OF SPARK COUNTERS.

A.El-Nadi and F.M.Aly.
J. sci. Instrum., Vol. 36, No. 10, 434-6 (Oct., 1959).

The spark counter, operating as an α-particle detector, was studied extensively both with respect to the corona current in a given gas, and for different gases. The performance of a single wire counter was first studied, and then the experiments were extended to multiple wire counters. Nitrogen showed good characteristics with a single-wire counter, but failed for multiple wires, whereas dry air showed the best characteristics with a counter with six wires.

539.1.07

### 3886 PARALLEL-PLATE SPARK COUNTERS FOR MEASURING SHORT TIME INTERVALS.

M.V.Babykin, A.G.Plakhov, Y.F.Skachkov and V.V.Shapkin.
J. nuclear Energy, Vol. 4, No. 3, 345-52 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4 (1956).

The construction of parallel-plate spark counters is described, and characteristics are given of counters filled with argon and diethyl ether vapour.

539.1.07

### 3887 AN INVESTIGATION OF THE TIME-RESOLVING POWER OF PARALLEL-PLATE SPARK COUNTERS.

E.K.Zavoisky and G.E.Smolkin.
J. nuclear Energy, Vol. 4, No. 3, 353-7 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4 (1956).

The resolving time of parallel-plate spark counters having a small working gap and high gas-filling pressure can be made as low as $10^{-10}$ sec.

539.1.07

### 3888 GAS-DISCHARGE SCINTILLATION COUNTER.

L.S.Sorokin.
Pribory i Tekh. Eksper., 1959, No. 3, 57-8 (May-June). In Russian.

Details are given of the construction of an experimental self-quenched counter with added antimony-cesium photocathode of sensitivity of about 10 microamp. per lumen, filled with 6 mm Hg of isopentane and 50 mm Hg of argon. Using a grid biased by a small negative voltage (few tenths of volt), the photoelectrons were separated from thermal electrons. Working under this condition with a NaI:Tl crystal of 10 mm thickness, the counters plateau had a length of about 100 V with a slope of 10%, and its efficiency for γ-photons of $Co^{60}$ was 14.5 greater than that of a conventional counter of type VS-4. 14 references. J.M.Zarzycki

539.1.07

### 3889 CAB-O-SIL SUSPENSIONS FOR LIQUID SCINTILLATION COUNTING.

D.G.Ott, C.R.Richmond, T.T.Trujillo and H.Foreman.
Nucleonics, Vol. 17, No. 9, 106, 108 (Sept., 1959).

Cab-O-Sil M-5 at 5% concentration is used as a thixotropic agent with toluene and aqueous dioxane scintillating solutions. 2 g of heavy solids can be held in 20 ml of the scintillator.

R.D.Smith

539.1.07

### 3890 MULTIWIRE COUNTER FOR CHARGED PARTICLES.

A.S.Deineko.
Pribory i Tekh. Eksper., 1959, No. 3, 44-6 (May-June). In Russian.

Detailed description is given of the construction of a new type of double annular multiwire counter filled with 90% of argon and 10% of ethyl alcohol at total pressure of 80-100 mm Hg. The construction of the counter allows its use for the observation of β-active products from the bombardment by charged particles of solid as well as gaseous targets. The plateau length is 150-175 volts, slope 3% per 100 volts and its efficiency when in a coincidence circuit is 0.28 for a maximum β-particle energy of 1.3 MeV. It was used for observation of positrons in $B^{10}(d,n)C^{11}$ and $C^{12}(p,\gamma)N^{13}$ reactions.

J.M.Zarzycki

539.1.07

### 3891 DOSE CHARACTERISTICS OF LOW-VOLTAGE HALOGEN COUNTERS.

A.B.Dmitriev, D.I.Peskov, A.B.Kheifets and V.G.Chaikovskii.
Pribory i Tekh. Eksper., 1959, No. 3, 47-9 (May-June). In Russian.

Results are given of an experimental investigation of the variation of the characteristics of different types of halogen-quenched counter with dose rate. The variation of counting rate shows a maximum for the majority of counters. Increase of load resistance causes a reduction of resolution and lowers limiting dose rate measurable. J.M.Zarzycki

539.1.07

### 3892 FILM γ-RAY DOSIMETRY USING A SHIELDED DEVICE FOR CALIBRATION.

V.Paić.
C.R. Acad. Sci. (Paris), Vol. 249, No. 19, 1951-3 (Nov. 9, 1959). In French.

To reduce possible exposure of the operator to γ-rays, an instrument is described permitting safe and rapid calibration of films. The calibration curve obtained for part of the film covered with a 1 mm thick cadmium or tin filter is generally usable without correction factors. The error involved in the procedure is less than 10%. S.J.St-Lorant

539.1.07

### 3893 A LUMINESCENCE CAMERA.

E.K.Zavoisky, M.M.Butslov, A.G.Plakhov and G.E.Smolkin.
J. nuclear Energy, Vol. 4, No. 3, 340-4 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4, 34 (1956).

A detailed description is given of the essential components of a luminescence camera. The developments since an earlier publication (see Abstr. 9726 of 1955) are described, together with new experimental data.

539.1.07

### 3894 CONSTRUCTION OF A NEW TYPE OF AUTOMATICALLY CONTROLLED VARIABLE PRESSURE WILSON CLOUD CHAMBER. T.Yuasa.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 58A-59A (March, 1957). In French.

The initial pressure can vary between 2 and 76 cm Hg.

539.1.07

### 3895 DIFFUSION CLOUD CHAMBERS.

V.K.Lyapidevskii.

Uspekhi fiz. Nauk, Vol. 66, No. 1, 111-29 (Sept., 1958). In Russian. English translation in: Soviet Physics—Uspekhi (New York), Vol. 66(1), No. 1, 124-36 (Sept.-Oct., 1958).

An extensive review article on the present state of the technique. Theoretical and experimental results are exhaustively surveyed, and the possibilities and the limitations of the instrument are critically considered. The principles of construction of various types of diffusion cloud chamber (including low pressure ones) are discussed, although no reference is made to any one particular type of design. A large up to date bibliography is included.

G.Martelli

539.1.07

### 3896 THE FUNDAMENTALS AND TECHNIQUES OF THE BUBBLE CHAMBER. G.Horlitz.

Z. InstrumKde, Vol. 67, No. 10, 245-51 (Oct., 1959). In German.

Review with 44 references.

539.1.07

### 3897 MEASUREMENT OF SYSTEMATIC TRACK DISTORTION IN A PROPANE BUBBLE CHAMBER.

W.H.Evans, D.W.Hadley, T.D.N.Morgan, P.R.Williams and A.Kirk.

J. sci. Instrum., Vol. 36, No. 8, 365-7 (Aug., 1959)

A propane bubble chamber, 6 × 2 × 2 in., has been operated with both single-piston and multiple-bellows expansion systems, the systematic distortions caused by turbulent motions being measured and compared in the two cases.

539.1.07

### 3898 A 24 LITRE PROPANE BUBBLE CHAMBER.

Van Gan-Chan [Pang Kang-Ch'ang], M.I.Solov'ev and Yu.N.Shkobin.

Pribory i Tekh. Eksper., 1959, No. 1, 41-3. In Russian.

A 24 litre propane bubble chamber, having a useful volume of $55 \times 28 \times 14$ cm$^3$, is described. The chamber is designed to work in a d.c. magnetic field. The pressure is hydraulically controlled. Orthogonal illumination is used, and to obtain good contrast, the back of the chamber is covered with black glass. Two drawings of the chamber are given together with a photograph of an oscilloscope trace showing the pressure cycle.

G.Martelli

539.1.07

### 3899 NEW POLYVINYL ALCOHOL NUCLEAR TRACK EMULSIONS. E.Fujii, H.Fujii, J.Demers and P.Demers.

Canad. J. Phys., Vol. 37, No. 12, 1465-73 (Dec., 1959). In French.

The preparation and some of the properties of two nuclear track emulsions with a polyvinyl alcohol base are described. These emulsions contained about 84% silver bromide but neither nitrogen nor gelatine, and recorded the tracks of $\alpha$-particles and protons and even slow electrons. It is hoped that the use of polyvinyl alcohol as the base will yield interesting mechanical properties. A method of detection is described which is highly directional and uses nuclear emulsions.

E.J.Burge

539.1.07

### 3900 THE ANGULAR SPREAD OF A BEAM OF PARTICLES PASSING THROUGH NUCLEAR EMULSION.

B.Chemel and Tsai-Chü.

C.R. Acad. Sci. (Paris), Vol. 249, No. 16, 1494-6 (Oct. 19, 1959). In French.

The deformation vector in the emulsion plane perpendicular to the beam and the multiple scattering constant are obtained from measurements of the angular spread of beams of 6 BeV protons and of 300 MeV $\pi$-mesons. The value of the scattering constant is found to approach a maximum value for particles of high velocity.

S.J.St-Lorant

539.1.

### 3901 EFFECT OF CADMIUM IONS ON THE PROPERTIES O NUCLEAR EMULSIONS.

J.Kubal, J.Beneš and Z.Hrkal.

Czech. J. Phys., Vol. 8, No. 6, 658-64 (1959). In Russian with summary (2 pp.) in English.

The inhibiting and sensitizing effect of Cd ions in the preparat of fine-grained emulsion was evaluated by sensitometric method fo visible light and electrons. To obtain an iso-dispersion emulsion it is required to use at least 1 mole % of the Br$^-$ as CdBr$_2$. Cd ions (0.7-5.0 mole %) sensitize the emulsion with respect to visible light, $\alpha$ particles and electrons. Individual electrons from C$^{14}$ and from the Th disintegration series were recorded with the authors' emulsion.

F.Lachma

539.1.0

### 3902 USE OF CURVED NUCLEAR PHOTOGRAPHIC EMULSIONS. J.Heidmann.

J. Phys. Radium, Vol. 18, No. 11, 625-8 (Nov., 1957). In French.

A method for discriminating background tracks in nuclear photographic emulsions is described. It works by simply bending the emulsions.

539.1.0

### 3903 FOLLOW-THROUGH PLATE HOLDER FOR NUCLEAR TRACK MICROSCOPES. A.E.Dyson.

Rev. sci. Instrum., Vol. 31, No. 2, 144-5 (Feb., 1960).

The follow-through plate holder is a device for following nuclear tracks from one emulsion plate to another. This accomplis ed by placing one plate above the other in such a way that the upper plate may be moved horizontally together with the lower one or independent of it, while either is viewed in the microscope.

539.1.07 ; 541.1

### 3904 PREPARATION OF NUCLEAR TRACK EMULSIONS FO ELECTRON MICROSCOPY. G.Riedel.

Naturwissenschaften, Vol. 46, No. 18, 529-30 (1959). In German.

In order to obtain better resolution than in an optical microscope, a method has been developed for observing autoradiographs of aerosols in the electron microscope. The active particles are collected on a filter membrane and coated with a special emulsion. After exposing, developing and fixing, a thin carbon film is evaporated on to the surface and the gelatine and membrane carefully dissolved away. The silver particles are retained in the carbon film, which is examined in the electron microscope. Micrographs of tracks from colloidal particles are shown at magnifications of 1300 × and 10700 ×.

V.E.Cosslett

539.1.0

### 3905 SELF-CONTAINED PREAMPLIFIER FOR PROPORTIONAL COUNTERS. G.E.Bradley.

Amer. J. Phys., Vol. 27, No. 5, 365 (May, 1959).

539.1.07 : 621.374.3

### 3906 A FLEXIBLE 20-CHANNEL TIME-DELAY AND PULSE HEIGHT ANALYSER. EQUIPMENT FOR PULSED BOMBARDMENT STUDY OF SHORT-LIVED NUCLEI IN A CYCLOTRON. P.A.Tove.

Ark. Fys., Vol. 13, Paper 41, 579-607 (1958).

A multichannel pulse analyser is described which is suitable for time-delay analysis of events in the range from 1 $\mu$ sec to minutes or more. Applications are lifetime measurements on isomers in this region, and, with auxiliary equipment, pulsed bombardment studies of short-lived nuclei produced in an accelerator. The time sorting is done by count channels which are successively opened and shut. The analyser is easily converted to a pulse-height analyser.

539.1.07 : 621.374.3

### 3907 PULSE HEIGHT SELECTOR WITH CONSTANT ANALYSIS TIME. M.Spighel and L.Pénege.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 19A-22A (March, 1957). In French.

A one-channel pulse-height selector with constant analysis time (accuracy of $2 \times 10^{-8}$), independent of pulse height is described. This has been obtained with pulses having $2.5 \times 10^{-7}$ sec rise-time by correctly selecting a reference time in the pulse. By taking into account the delay of a trigger, the analysis time may be defined with a precision of $5 \times 10^{-9}$ sec.

539.1.07

### 3908 EXPERIMENTAL CALIBRATION OF SCINTILLATION PULSE HEIGHTS OF THIN CsI CRYSTALS.

.C.Worth and G.R.Haste

ev. sci. Instrum., Vol. 31, No. 2, 169-70 (Feb., 1960).

The pulse-height response of three thin CsI crystals has been determined for protons from $B^{10}$(d,p) and $C^{12}$(d,p) reactions, using l foils to vary the energy of the incident protons. Three points on the range-energy curve for CsI have been determined and compared with the range-energy curve for silver.

539.1.07

### 3909 PULSE-SHAPE DISCRIMINATION IDENTIFIES PARTICLE TYPES. R.B.Owen.

Nucleonics, Vol. 17, No. 9, 92-5 (Sept., 1959).

Scintillation pulses produced by charged particles decay in a combination of exponentials of different time constants. Discrimination between different types of particles is possible because amplitude ratios of slow and fast components differ. Circuits which produce two pulses proportional to total charge and peak height respectively can be used to identify the particles causing the scintillations. In organic scintillators electrons produce a higher peak pulse relative to mean pulse than protons, while in inorganic phosphors the reverse is true. Results obtained with a number of scintillators and several practical methods of pulse shape discrimination are described. R.D.Smith

539.1.07

### 3910 KANDIAH DISCRIMINATOR PERMITS SIMPLIFIED MONITOR CIRCUIT. M.H.Goosey.

Nucleonics, Vol. 17, No. 9, 104 (Sept., 1959).

A photomultiplier with NaI (for $\gamma$) or stilbene (for $\beta$) crystals feeding the discriminator via a cathode follower is used in a robust radiation monitor. R.D.Smith

539.1.07

### 3911 GEIGER COUNTER HODOSCOPE WITH AUTOMATIC TESTING. H.S.Murdoch and H.D.Rathgeber.

. sci. Instrum., Vol. 36, No. 5, 209-11 (May, 1959).

A multi-channel hodoscope is described which records automatically on punch cards, uses a simple but effective quenching circuit and contains a testing circuit. An automatic hourly test is applied to all channels, providing a random sample of their behaviour and enabling speedy detection of faults either in the counters themselves or the associated recording circuits.

## NUCLEAR FIELD THEORY

539.11

### 3912 MATHEMATICAL PROBLEMS OF QUANTUM THEORY OF PARTICLES AND FIELDS.

Nuovo Cimento Suppl., Vol. 14, No. 1, 211 pp. (1959).

This is a series of papers presented at the Summer School of Physics at Varenna, July-August, 1958. Titles and authors of the papers are as follows: Functional analysis, L.Garding and J.L.Lions, (9-66); Theory of Lie groups, G.Racah, (67-74); Four dimensional orthogonal groups, G.Racah, (75-80); Relativistic invariance and quantum mechanics, A.S.Wightman, (81-94); Covariant description of polarization, L.Michel, (95-104); Selected problems in renormalization theory, G.Kallen, (105-30); The framework of quantum field theory, R.Haag, (131-52); Scattering matrix and fields operators, H.Lehmann, (153-76); Theory of coupled quantized fields, E.R. Caianiello, (177-91); Vacuum expectation values and analytical functions, A.S.Wightman, (192-6); Covariant formalism of a field with indefinite metric, M.Froissart, (197-204); Report and comment on F.Gursey's "Group structure of elementary particles", W.Pauli and B.Touschek (205-11).

539.11

### 3913 COMMUTATION RULES AND SPURIOUS EIGENSTATES IN SOLUBLE FIELD THEORIES.

R.E.Norton and W.K.R.Watson.

Phys. Rev., Vol. 116, No. 6, 1597-603 (Dec. 15, 1959).

A study is made of the exactly soluble field theories which are characterized by Hamiltonians quadratic in the field variables. As an example of such a theory, a model describing the electric dipole interaction of photons and nonrelativistic, harmonically bound electron is studied explicitly. For the cases when the cutoff is sufficiently large to admit the "runaway solutions", it is necessary in order to obtain consistency and a sensible physical interpretation that the theory be reformulated by a unique modification of the equal-time commutation rules of the field operators. The problems which arise here in connection with the "runaway solutions" are closely related to the troubles of ghost states and negative transition "probabilities" which have been demonstrated or suggested to exist in other theories. It is hoped, therefore, that the procedure of reformulation required here may be a guide for the eventual resolution of the ghost-state problem should it be demonstrated that such problems actually exist in the physical, relativistic field theories.

539.11

### 3914 NON-LINEAR ELECTROMAGNETISM AND PHOTONS IN THE FUNCTIONAL THEORY OF PARTICLES.

F.Aeschlimann and J.L.Destouches.

J. Phys. Radium, Vol. 18, No. 11, 632-7 (Nov., 1957). In French.

It is shown that Mie's or Born's equations of nonlinear electromagnetism are obtained from the nonlinear equations of the photon (functional theory), by means of linear combinations of these equations defined by the fundamental operators of the de Broglie photon. The magnetic and electric fields are defined exactly as in de Broglie's theory of photon whereas the inductions are defined by other linear terms according to the second definitions of the fields by de Broglie. Only the polarizations and the expressions deriving from them are expressed by means of nonlinear terms. In this way a microphysical theory can be constructed, which unifies de Broglie's linear theory of the photon and Mie's or Born's nonlinear electromagnetism.

539.11

### 3915 THE ASYMPTOTIC BEHAVIOUR OF THE PHOTON PROPAGATOR IN QUANTUM ELECTRODYNAMICS.

B.A.Arbuzov.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 6, 1149-52 (Oct. 21, 1959). In Russian.

A Nambu type spectral representation is derived for the photon propagator using the generalized Ward identity. The asymptotic behaviour is studied under the requirement that the propagator satisfy the Schwinger equation of motion, and it is found that the spectral weight function (and hence the propagator) is non-analytic as a function of the charge e. The singularity is shown to arise directly from the equations of motion and is quite independent of any assumption about the validity of perturbation expansions in powers of e. R.F.Peierls

539.11 : 539.12

### 3916 ON A POSSIBLE TEST OF QUANTUM ELECTRODYNAMICS IN ELECTRON SCATTERING.

G.V.Avakov and K.A.Ter-Martirosyan .

Nuclear Phys., Vol. 13, No. 5, 685-94 (Nov. [3], 1959).

It is shown that a violation of quantum electrodynamics of the type corresponding to an effective nonlocal structure of an electron may be found through a study of the elastic scattering of electrons on $\alpha$-particles (with a very small improvement in accuracy of measurements as compared with the level attained so far). Because of the absence of spin and magnetic moment, elastic scattering on $\alpha$-particles is generally a very convenient process for detecting any kind of violation of the theory in the region of not too small distances (of the order of $10^{-13}$ cm to $10^{-14}$ cm). Unlike the case of $\alpha$-particles, the scattering of electrons on nucleons offers in principle no possibility of detecting violations of the theory of the type under consideration (if one excludes such complex experiments as measuring changes in the polarization of electrons in scattering or the scattering of polarized electrons on polarized nucleons).

539.11

### 3917 RELATIVISTIC HYDRODYNAMICS OF THE DIRAC MATTER. I. GENERAL THEORY. T.Takabayasi.

Suppl. Prog. theor. Phys., No. 4, 1-80 (1957).

Develops in detail a theory of the Dirac electron in classical terms. The formalism may be interpreted as a new kind of relativistic hydrodynamics. Brief accounts have appeared previously (Abstr. 910 and 4192 of 1956). R.J.N.Phillips

539.11

### 3918 PARTICLE REPRESENTATION OF THE VECTOR FIELD, AND COMPARISON WITH THE FIELD OF MAXIMUM SPIN 1 OF THE FUSION. K.H.Tzou.

J. Phys. Radium, Vol. 18, No. 11, 619-24 (Nov., 1957). In French.

The general vector field is formulated in a matrix representation with a first-order wave equation. It is then shown explicitly how its two spin states 1 and 0 are mixed together. On the other hand, the general vector field obeys an algebraic law which is different from that of the irreducible fields of spin 1 and 0, though these fields are just the two spin components of the general vector field. This algebra constitutes therefore a new way in the formulation of a general mixed theory of the spins 1 and 0. Finally, a comparison is made between the general vector field and the field of maximum spin 1 of the fusion theory as concerning their internal structure with regard to spin states.

539.11

### 3919 ON THE PROBLEM OF TRANSFORMATION PROPERTIES OF THE SPIN PSEUDO-VECTOR.

A.A.Sokolov, I.M.Ternov and J.M.Loskutov.

Ann Phys. (Leipzig), Folge 7, Vol. 5, No. 5-6, 241-8 (1960).

The polarization 4- vector of Dirac's particles is introduced by the covariant method, and its transformation properties are investigated. The results obtained are used to discuss the phenomena related to parity non-conservation.

539.11

### 3920 SINGLE PARTICLE ENERGIES IN THE THEORY OF NUCLEAR MATTER. K.A.Brueckner and D.T.Goldman.

Phys. Rev., Vol. 117, No. 1, 207-13 (Jan. 1, 1960).

The excitation spectrum of real and virtual excitations is discussed from the point of view of the perturbation series expansion. The effect of the rearrangement energy terms in the single-particle virtual excitation spectrum is evaluated and seen to be very small. It is also noted that the virtual particle energies are real due to the effects of off-energy-shell propagation. Starting from the reaction matrix approximation for the ground state energy, the energies of real particle and hole excitations are defined which satisfy the separation energy theorem. It is shown that the energies so defined depend on an infinite sequence of terms giving the rearrangement energy for multiple excitations. Appropriate termination and evaluation of this series are discussed.

539.11

### 3921 DENSITY EXPANSIONS OF HARD-SPHERE FERMI SYSTEMS. A.Temkin.

Ann. Phys. (New York), Vol. 9, No. 1, 93-105 (Jan., 1960).

Aviles' calculation (Abstr. 1100 of 1959) of the $\rho^{4/3}$ term in the expansion of the energy of a hard-sphere Fermi gas in one-third powers of the density $\rho$ via the cluster expansion for the Jastrow wave-function (Abstr. 6762 of 1955) is completed. A similar type of density expansion is also applied to nuclear matter.

539.11

### 3922 SOME ASPECTS OF THE COVARIANT TWO-BODY PROBLEM. I. THE BOUND-STATE PROBLEM.

S.Okubo and D.Feldman.

Phys. Rev., Vol. 117, No. 1, 279-91 (Jan. 1, 1960).

A study has been made of the bound states of the Bethe—Salpeter equation (Abstr. 1469 of 1952) for the nucleon—antinucleon system, including the ladder and pair-annihilation diagrams. For simplicity, nucleons and mesons were taken to be scalar, the latter having zero rest mass. Pair effects enter only in S-states with the bound states corresponding to the poles of the meson propagator $D_F'$. The Bethe—Salpeter equation is closely related to the integral equation for the generalized vertex operator $\Gamma$; this has been solved by using an integral-transform method similar to that of Wick and Cutkosky, under the assumption that the nucleon mass is large compared to the binding energy. After performing a self-energy subtraction, the energy eigenvales are found as a function of the coupling constant. These have the form given by the usual Bohr formula plus corrections. Finally, some comments are made with respect to the extension of the formalism to mesons with nonzero mass and spinor nucleons.

539.11

### 3923 SOME ASPECTS OF THE COVARIANT TWO-BODY PROBLEM. II. THE SCATTERING PROBLEM.

S.Okubo and D.Feldman.

Phys Rev., Vol. 117, No. 1, 292-306 (Jan. 1, 1960).

By way of extension of previous study of the bound-state problem within the framework of the covariant Bethe—Salpeter formalism (see preceding abstract), the scattering of nucleons by nucleons has been investigated in the ladder approximation, assuming scalar nucleons and zero-mass scalar mesons. The solution of the scattering problem can be effected by using an integral-transform method which is similar to that developed for the bound-state problem, subject to the assumption that the nucleon mass is large compared to the kinetic energy in the centre-of-mass system. An essential complication which is now encountered is the appearence of an infrared divergence. Two methods of circumventing this difficulty are discussed. The cross-section can be calculated from the Green's function by a limiting process; the usual S-matrix formalism leads to incorrect results in this case, and an amplitude renormalization is required. In this connection, it is instructive to re-examine, in detail, the Coulomb-scattering problem in momentum space, since this is very closely related to the Bethe—Salpeter scattering problem. The Green's-function method turns out to be unsuitable for the calculation of higher-order corrections to the nucleon—nucleon scattering cross section, so that here a cutoff procedure must be used.

539.11

### 3924 THREE-FIELD THEORY OF STRONG INTERACTIONS. W.Thirring.

Nuclear Phys., Vol. 14, No. 4, 565-77 (Jan. (2), 1960).

A theory of strong interactions which uses only three massless fundamental fields is discussed. This theory gives all additive constants of the motion but not C and P separately. It is proved that the electric and pionic vertices have to conserve parity but not the vertices for $\beta$ and strange particle interactions. It seems that the latter feature is not necessarily in contradiction with parity conservation in nuclear physics, in contrast with the opinion expressed in a previous paper on this question. Accepting the simplest representation for spin 0 bosons one finds that they are pseudoscalar rather than scalar inasmuch as parity is conserved.

539.11

### 3925 TWO PARTICLE APPROXIMATIONS OF THE MANY BODY PROBLEM. II. W.Brenig.

Nuclear Phys., Vol. 13, No. 3, 333-49 (Nov. (1), 1959).

For Pt I see Abstr. 4742 of 1958. A formulation of the theory of nuclear reactions is presented which exhibits very explicitly the connection between the shell model and the compound nucleus model. A Breit—Wigner formula is derived in which the hard-sphere scattering is replaced by the shell model scattering. Although the compound states are, in general, complicated many-body excitations, the two-particle approximation of Brueckner et al. can be shown to be sufficient for the calculation of the average properties contained in the optical model. Furthermore it is proved that the S-matrix, analogously to the ground-state energy, could be calculated in a "model approach" in which the correlations of the target nucleons are taken into account, but nevertheless the final result is expressed in terms of the momentum distribution of uncorrelated nucleons as in the original Goldberger method. The real and imaginary parts of the optical potential are calculated and the energy dependence of the so-called rearrangement energy is estimated, resulting in a slight increase of the effective mass.

539.11

### 3926 NUCLEAR FORCES AND THE FEW-NUCLEON PROBLEM. T.C.Griffith and E.A.Power.

Nature (London), Vol. 184, 1113-14 (Oct. 10, 1959).

M.J.Moravcsik.

Physics Today, Vol. 12, No. 10, 38-40, 42, 44 (Oct., 1959).

Reports on the international conference held in London, July, 1959. The conference divided into two parts : a discussion of the two-nucleon interaction followed by one on the few-nucleon problem. There was also a brief discussion of the many-body problem to the extent that it can be applied to light nuclei.

539.11 : 539.12

### 3927 THE UNIVERSAL FERMI INTERACTION AND HEAVY MESONS. S.Nakamura.

Nuclear Phys., Vol. 14, No. 1, 155-68 (Dec. [1], 1959).

By postulating interchange ability of the fermions, forty-four kinds of new heavy bosons are introduced which were not included in the Gell-Mann—Nishijima scheme. It is aimed thus to understand the $\beta$-decay and the other processes by the universal Fermi interaction in terms of the competitive processes involving the intermediary of boson groups. The existence of new kinds of muons with extraordinary long life-times of 1 to 100 days is also conjectured.

539.11

### 3928 SPECTRAL PROPERTIES OF GREEN'S FUNCTIONS IN A FIXED SOURCE MODEL OF MESON FIELD THEORY.

.N.Tavkhelidze, I.T.Todorov and N.A.Chernikov.
Dokl. Akad. Nauk SSSR, Vol. 129, No. 4, 769-72 (Dec. 1, 1959).
In Russian.

The properties of the Green's function are studied in a fixed source, charge symmetric meson field theory, in which the nucleon spin is ignored as well as the momentum dependence of the meson energy. Examination of the spectral properties shows that a rigorous treatment of this model gives an exact solution with no "negative probability" paradox. R.F.Peierls

539.11

### 3929 MAGNITUDE OF THE PION RENORMALIZATION CONSTANTS. J.W.Moffat.

Nuclear Phys., Vol. 14, No. 4, 682-4 (Jan. (2), 1960).

It has recently been pointed out that within the exact formulation of renormalization theory the pion mass renormalization constant $\delta m^2$ for pion—nucleon coupling is either infinite or indeterminate. This result is shown here to hold also in the case of pion—photon coupling. A detailed investigation reveals that for pion—nucleon coupling $\delta m^2$ is indeterminate only under very special circumstances.

539.11

### 3930 MULTIPLE SCATTERING OF POLARIZED PARTICLES L.Waldmann.

Nuovo Cimento, Vol. 14, No. 4, 898-900 (Nov. 16, 1959).

Gives the outline of a diffusion theory for polarized particles. R.J.N.Phillips

539.11

### 3931 TOPICS IN THE THEORY OF DISPERSION RELATIONS. G.R.Allcock.

Nuclear Phys., Vol. 14, No. 2, 177-98 (Dec. [2], 1959).

The mathematics and physics of the theory of dispersion relations are discussed, with particular reference to the quantized field description of the scattering by a fixed centre. Various known analytic continuations of physical data are examined for mathematical stability, and the dispersion relation at fixed momentum transfer is proved by a simple method which is throughout susceptible to the operations of numerical analysis. It is suggested that such stability is a necessary feature of a satisfactory proof. The scattering problem is formulated entirely in terms of the fields at large but finite distances from the scatterer, and this leads to a direct and perspicuous treatment of the "unphysical" region. The effect of finite violations of microscopic causality is expressed quantitatively through a new dispersion relation which, while still dealing only with accessible scattering data, embodies within itself a fundamental length.

539.11

### 3932 ON THE CONVERGENCE OF THE BORN APPROXIMATION. H.Davies.

Nuclear Phys., Vol. 14, No. 3, 464-71 (Jan. (1), 1960).

It is shown that the Born series for the nonrelativistic scattering amplitude $f(k)$ by a spherically symmetric static potential $V(r)$, which is bounded and has finite range, is convergent for all $k$ if the potential $-|V(r)|$ cannot support a bound state.

539.11

### 3933 SCATTERING INVOLVING A BOUND STATE. S.Tani.

Phys. Rev., Vol. 117, No. 1, 252-60 (Jan. 1, 1960).

Granting that the formation of a bound state is a "sudden" process (as compared to the scattering which may be regarded as a process taking place "adiabatically"), a formulation of the scattering involving a bound state is discussed, in which an independent set of creation—annihilation operators is introduced for a particle in the bound state. There appears here a subsidiary condition which prevents the system from having an unduly increased number of degrees of freedom. In the case of potential scattering, which is studied in this paper, this subsidiary condition restricts the intermediate states in a multiple scattering process to states which are orthogonal to the bound state. This orthogonality condition gives rise to a simple explanation of the theorem concerning the scattering phase shift at zero energy, in which it is stated that when there is one bound state, the scattering phase shift starts with $\pi$ at zero energy, if it is to go down to zero at extreme high energy.

539.11

### 3934 STRUCTURE OF THE FORWARD SCATTERING AMPLITUDE. S.Deser, W.Gilbert and E.C.G.Sudarshan.

Phys. Rev., Vol. 117, No. 1, 266-72 (Jan. 1, 1960).

The matrix elements of various products of two currents between states of equal energy-momentum are studied. Use of the axioms of local field theory leads to an integral representation for the Fourier transform of matrix elements of the retarded commutator in terms of two invariant momentum parameters. Further restriction on the class of allowed functions permits explicit incorporation of the mass restrictions as support conditions on the weight function. The "bound-state" term is separated off and related to the vertex functions. As a simple application, forward-scattering dispersion relations are derived by specialization of the Green's function. In particular, these can be obtained for nucleon—nucleon and K-meson—nucleon scattering.

539.11

### 3935 INTEGRAL REPRESENTATIONS OF TWO-POINT FUNCTIONS. S.Deser, W.Gilbert and E.C.G.Sudarshan.

Phys. Rev., Vol. 117, No. 1, 273-9 (Jan. 1, 1960).

See also preceding abstract. An integral representation for a general matrix element of two field operators between eigenstates labelled by an arbitrary number of momenta is presented. This representation is conveniently parametrized over a set of invariants related to the total momentum and momentum transfer, and explicitly incorporates spectral conditions. Physically interesting dispersion relations for off-forward scattering cannot be obtained from this representation alone.

539.11

### 3936 NON-RELATIVISTIC APPROXIMATION OF BHABHA'S EQUATION. K.K.Gupta.

Proc. Indian Acad. Sci. A, Vol. 45, No. 5, 336-40 (May, 1957).

This equation describes a particle with two states of different mass and spin. It is reduced to non-relativistic form in the presence of an external magnetic field, and the magnetic moments of the two states are found. R.J.N.Phillips

539.11

### 3937 ANALYTIC PROPERTIES OF PERTURBATION EXPANSIONS. J.C.Taylor.

Phys. Rev., Vol. 117, No. 1, 261-5 (Jan. 1, 1960).

A method is introduced for locating and interpreting the singularities in finite-order perturbation expansions of Green's functions, in cases where the external momenta are complex vectors with real scalar products. In particular, when the external momenta form a real Euclidean set, there is a simple graphical construction, applicable to all finite orders. As an example of a case in which the external momenta form a real set in a space of signature $(+,+;-,-)$, a feature of Mandelstam's representation for scattering amplitudes is interpreted in perturbation theory. Finally, the ranges of values of momentum-transfer for which (in perturbation theory) dispersion relations certainly hold are enlarged, in particular by using the fact that the pion is pseudoscalar.

539.11

### 3938 PSEUDO-CLUSTER EXPANSION. J.Fujita.

Nuclear Phys., Vol. 14, No. 4, 648-60 (Jan.(2), 1960).

The Ursell—Mayer cluster expansion method is extended to the case of a q-number model operator for either boson or fermion systems. The many-body problem for a system with strong, hard-sphere interactions can be approximately reduced to that for a weakly interacting system without hard-sphere interactions. The effective Hamiltonian for the weakly interacting system is given in the form of an expansion series quite analogous to the ordinary cluster expansion (called the "pseudo-cluster expansion" in this paper). The validity of the author's expansion method is discussed. It can be proved that in the simplest case one is led to the approximate Bethe—Goldstone equation (or Brueckner approximation). Formulae expressing the total energy and the diagonal and nondiagonal matrix elements of operators by the asymptotic wave-functions are derived. The possibilities of applying the present method are discussed.

## ELEMENTARY PARTICLES

539.12

### 3939 ELEMENTARY-PARTICLE PHYSICS. H.Burkhardt.

Amer. J. Phys., Vol. 28, No. 3, 202-12 (March, 1960).

A review is given of the modification of the classical picture of forces and particles by the ideas of quantum theory leading to Yukawa's meson hypothesis. Following this, aspects of the present knowledge of the elementary particles and their interactions are discussed from a phenomenological point of view.

539.12

3940 ON THE SYSTEMATIZATION OF THE STRONGLY INTERACTING PARTICLES. M.Ida.

Progr. theor. Phys., Vol. 17, No. 5, 733-4 (May, 1957).

Taking the view that a system of strongly interacting particles (SIP's) should possess a symmetry higher than that of charge-independence in the absence of interactions, a scheme similar to that of Salam and Polkinghorne (Abstr. 2653 of 1956) is presented for classifying all SIP's, which does not suffer from the deficiency of predicting multiply charged SIP's or particles with high strangeness. P.K.Kabir

539.12

3941 MASS SPLITTINGS WITHIN BARYON CHARGE MULTIPLETS. R.E.Behrends and L.Landovitz.

Phys. Rev., Vol. 117, No. 2, 589-94 (Jan. 15, 1960).

The effect upon the mass splittings within each isobaric multiplet of a phenomenological boson mass difference is calculated. It has been possible to sum the diagrams to all orders in the strong couplings but the results are only valid to first order in the mass difference. These results can be compactly expressed as derivatives with respect to the intermediate masses of a function related to the proper self-energy. The second-order perturbation results are also calculated.

539.12

3942 DETERMINATION OF MASS AND MOMENTUM OF CHARGED PARTICLES IN A BUBBLE CHAMBER BY MEANS OF MULTIPLE SCATTERING MEASUREMENTS.

V.G.Kirillov-Ugryumov, L.P.Kotenko, E.P.Kuznetsov and A.V.Samoilov.

Pribory i Tekh. Eksper., 1959, No. 1, 44-7. In Russian.

The analysis of the multiple scattering has been carried out on the lines of the work of Annis et al (Abstr. 4884 of 1953). It is found that to determine to 30% the mass of $\mu$ or $\pi$ mesons, 36 cm of range in propane are required, whilst 72 cm are necessary for protons. It is also found that to measure the product $p\beta c$ ($p$ = momentum, $\beta c = v$ = velocity of the particle) with the precision of, say, 15%, 25 cm of range are required, if $p\beta c \sim 100$ MeV. The method is checked against some experimental results and the agreement between the measured and known values of the masses is found very satisfactory. G.Martelli

539.12

3943 COUPLED ERRORS ON SCATTERING PHASE SHIFTS. D.Miller.

Nuclear Phys., Vol. 14, No. 2, 238-42 (Dec. [2], 1959).

During a least-squares analysis of scattering data, a hypothetical energy dependence for the phase-shifts often reduces the errors considerably. The mechanism of this error reduction becomes explicit only when the grid method of searching for a best fit is employed. The author's illustration is drawn from low energy counter measurements on the pion nucleon system.

## Photons

539.12

3944 THE PHOTON AS A COMPOSITE PARTICLE. N.Rosen and P.Singer.

Bull. Res. Coun. Israel, Vol. 8F, No. 1, 51-62 (Sept., 1959).

The photon is treated as a system consisting of a neutrino and an antineutrino, each of zero rest mass and described by a four-component wave-function, with a delta-function interaction between them. The Dirac equation for this system is solved by the auxiliary use of a proper coordinate system on the assumption at first that the total rest energy and the interaction range are different from zero, and then that these approach zero. Solutions are thus found representing "localized" states for which the external motion is described by the Maxwell equations for empty space while the internal motion is limited to a very small region. If one restricts the interaction to a single type, it turns out to be either vector or pseudovector. Two neutrinos or two antineutrinos do not form such a composite photon. Likewise, the use of two-component neutrino wave functions fail to give such a photon.

539.12

3945 ALBEDOS OF VARIOUS SUBSTANCES FOR $\gamma$-RAYS FROM ISOTROPIC Co$^{60}$, Cs$^{137}$ AND Cr$^{51}$ SOURCES.

B.P.Bulatov.

Atomnaya Energiya, Vol. 7, No. 4, 369-72 (1959). In Russian.

The sources were placed on 65 × 65 cm surfaces of thick pieces of C, Al, Fe and Pb. The detector was placed at various positions 30 cm from the point of contact; the $\gamma$ energy flux density was measur with and without the scatterer, and the albedo calculated as the ratio of total back-scattered to total incident flux, obtained by numerical integration. The albedo was found to decrease with increasing atomi number and initial $\gamma$ energy. Comparisons are given with some values calculated from other data. The intensity and spectral distribution as functions of distance from the source were also determined for a Co$^{60}$ source on graphite (300 × 300 cm). The effect of initial $\gamma$ energy and atomic number of the scattering medium on the angular distribution is discussed. J.B.Sykes

539.12

3946 ATTENUATION OF SCATTERED CESIUM-137 GAMMA RAYS. F.S.Frantz, Jr and H.O.Wyckoff.

Radiology, Vol. 73, No. 2, 263-6 (Aug., 1959).

The intensity of the radiation scattered from concrete was measured; it decreases approximately linearly as the scattering angle increases to 90° but thereafter decreases very little. Attenuation curves for the scattered radiation in both lead and concrete are given for absorber thicknesses up to 12 mm. It is shown that the attenuation of the scattered radiation, of an energy computed from the Compton relationship, agrees with that observed for cobalt-60 gamma rays of the same energy, within the accuracy usually required in radiation protection work. A.J.Salmon

539.12 : 530.12

3947 RESONANT ABSORPTION OF THE 14.4 keV $\gamma$-RAY FROM 0.10-$\mu$sec Fe$^{57}$. R.V.Pound and G.A.Rebka, Jr.

Phys. Rev. Letters, Vol. 3, No. 12, 554-6 (Dec. 15, 1959).

The resonant absorption was measured, making use of the Mössbauer effect, in which, for a proportion of the emitted $\gamma$-rays, the recoil is absorbed by the crystal lattice as a whole rather than by the individual nucleus. The source consisted of about 50 $\mu$c of Co$^{57}$ plated on to 1 × 1 cm of thin Armco iron. The absorber was a foil of Armco iron of 11.5 mg/cm$^2$ thickness. The absorption line width was observed by producing relative motion between source and absorber using a magnetic tranducer. Initially the absorption line was broadened due to the effect of impurities in the source and absorber. After these difficulties were overcome, plots of percentage increase of transmitted intensity as a function of source velocity showed an experimental line half-width of 10$^{-12}$ times the velocity of light. In addition, three satellite absorption lines were observed and could be interpreted as components of a multiplet due to hyperfine structure splitting in the ferromagnetic metal. The results suggest that the Larmor frequency of the spin 3/2 first excited state of Fe$^{57}$ is about 39 Mc/sec and that its magnetic moment is large compared with that of the ground state. This experiment is discussed as a possible laboratory method of determining the gravitational red-shift. R.E.Meads

539.12 : 530.12

3948 RECOILLESS RESONANCE ABSORPTION OF GAMMA RAYS IN Fe$^{57}$. J.P.Schiffer and W.Marshall.

Phys. Rev. Letters, Vol. 3, No. 12, 556-7 (Dec. 15, 1959).

The Debye—Waller factor predicts, in the case of the decay of the 14 keV first excited state of Fe$^{57}$, that at room temperature 63% of the $\gamma$-rays should be emitted without recoil. A source of Co$^{57}$ was produced by 4 MeV deuteron bombardment of iron foil was mounted on the diaphragm of a loudspeaker so that it could be moved relative to a similar iron foil absorber containing 2.2% of Fe$^{57}$. The 14 keV radiation was detected using a proportional counter filled with xenon. When the source was moved with a velocity large compared with the line-width a 20% increase in transmitted intensity over that with stationary source was observed. Measurement of the hyperfine structure of this line in ferro- and antiferromagnetic materials is suggested as a means of measuring the effective fields acting on the nucleus. An experiment by Cranshaw to measure the gravitational red-shift of this $\gamma$-ray is in progress. R.E.Meads

539.12

3949 GENERALIZATION OF SOMMERFELD'S THEORY OF CONTINUOUS X-RADIATION (BREMSSTRAHLUNG).
Kulenkampff, M.Scheer and E.Zeitler.
Phys., Vol. 157, No. 3, 275-82 (1959). In German.

Sommerfeld's (1931) theory of Bremsstrahlung contains two approximations which lead to errors in the intensity distribution with angle of emission. The theory can be improved by a more general treatment which includes relativity effects and dispenses with one approximation by introducing new experimental data.

T.Mulvey

539.12

3950 PLANE POLARIZATION OF 15.1 MeV BREMSSTRAHLUNG FROM 25 MeV ELECTRONS.
D.Jamnik and P.Axel.
Phys. Rev., Vol. 117, No. 1, 194-206 (Jan. 1, 1960).

Linearly polarized gamma rays were produced with the aid of a special betatron doughnut which made it possible to limit the effective thickness of the bremsstrahlung-producing Al and Pt targets. The linear polarization of 15.1 MeV bremsstrahlung gamma rays was detected by measuring the azimuthal angular distribution of gamma rays which had been scattered elastically from the well-known nuclear level in $C^{12}$. For the particular effective thickness of Al that was used, the maximum polarization of 15.1 MeV gamma rays in the bremsstrahlung of 25 MeV electrons was 1.53 ± 0.05. (This corresponds to 21% in the more conventional polarization notation.) Both this observed maximum (which occurred at an angle of 1.4°) and the polarization measured at four other angles confirm theoretical predictions. With the platinum target that was used, the observed polarization of 1.28 ± 0.04 was about 10% lower than the value predicted by theoretical calculations which use the Born approximation and neglect screening. However, available screening and Coulomb corrections bring the theoretical predictions into essential agreement with the experimental values. Since the elastic scattering pattern of gamma rays shows unambiguously that the strong photon scattering level at 15.1 MeV in $C^{12}$ is excited by magnetic dipole radiation, this level has spin 1 and even parity.

## X-rays

539.12

3951 THE CONTINUOUS X-RAY SPECTRUM FROM ELECTRON-OPAQUE TARGETS. N.A.Dyson.
Proc. Phys. Soc., Vol. 73, Pt 6, 924-36 (June, 1959).

The angular and energy distributions of the continuous X-ray spectrum were investigated in the forward hemisphere for accelerating potentials between 6 and 12 kV. The targets were sufficiently thick to bring the incident electrons to rest, and the spectral distributions closely resemble those obtained by earlier workers with massive targets. The angular distributions are greatly influenced by electron scattering, and it is shown that the degree of anisotropy is consistent with multiple scattering and diffusion being usually prevalent even when the electrons have lost only a small proportion of their incident energy. The absolute efficiency of X-ray production was found to be about 20% greater than expected from the formula of Compton and Allison. A proportional counter was used for the measurements, and the method is described.

539.12

3952 TECHNIQUE FOR OBTAINING ABSORPTION AND EMISSION SPECTRA OF X-RAYS. II. C.Kurylenko.
Cahiers de Phys., Vol. 12, 61-84 (Feb., 1958). In French.

See Abstr. 3542 of 1959. A historical account of the work of Barkla, W.H.Bragg, W.L.Bragg, M. de Broglie, Moseley, and others is given.

A.R.Stokes

539.12

3953 BETA-EXCITED CHARACTERISTIC X-RAYS AS ENERGY REFERENCE SOURCES.
J.F.Cameron and J.R.Rhodes.
Internat. J. appl. Radiation and Isotopes, Vol. 7, No. 3, 244-50 (Jan., 1960).

The β-particles emitted from 1 mc of $K_r^{85}$ sealed in a small nickel capsule were used to excite the characteristic K X-rays of various elements. It was found that the best arrangement of source and target was with the source sandwiched between two thin foils of the target element. The use of these X-rays as energy references for the calibration of proportional and scintilation counters in the energy region from 0 to 100 keV is illustrated. Since the energies of K X-rays are known to about one part in $10^4$ the accuracy of calibration depends on the resolution of the instrument under test.

539.12 : 541.15

X-RAY MEASUREMENT USING FERROUS SULPHATE SOLUTION. See Abstr. 3324

## Neutrinos

539.12

3954 NEUTRINO DETECTION BY RESONANCE ABSORPTION IN CRYSTALS AT LOW TEMPERATURES.
W.M.Visscher.
Phys. Rev., Vol. 116, No. 6, 1581-2 (Dec. 15, 1959).

An experiment is proposed wherein neutrinos emitted during electron capture by radioactive impurities in one part of a crystal may be resonantly absorbed by atoms in another part. Essential to the argument is the fact, recently experimentally proved by Mössbauer for gamma-rays, that in an emission or absorption by a nucleus bound in a crystal at low temperature the recoil energy is often taken up by the crystal as a whole, with no phonons emitted or absorbed. Thus no energy is lost to recoil, and a neutrino emitted in a monoenergetic process has exactly the right energy to be resonantly absorbed in the inverse process. The feasibility of the experiment depends on the degree to which the electronic impurity levels are broadened relative to the natural width of the neutrino line.

539.12

3955 DETECTION OF THE FREE ANTINEUTRINO.
F.Reines, C.L.Cowan, Jr, F.B.Harrison, A.D.McGuire and H.W.Kruse.
Phys. Rev., Vol. 117, No. 1, 159-73 (Jan. 1, 1960).

The antineutrino absorption reaction $p(\nu,\beta+)n$ was observed in two 200 litre water targets each placed between large liquid scintillation detectors and located near a powerful production fission reactor in an antineutrino flux of $1.2 \times 10^{13}$ $cm^{-2}$ $sec^{-1}$. The signal, a delayed-coincidence event consisting of the annihilation of the positron followed by the capture of the neutron in cadmium which was dissolved in the water target, was subjected to a variety of tests. These tests demonstrated that reactor-associated events occurred at the rate of 3.0 $hr^{-1}$ for both targets taken together, consistent with expectations; the first pulse of the pair was due to a positron; the second to a neutron; the signal depended on the presence of protons in the target; and the signal was not due to neutrons or gamma rays from the reactor.

## Electrons

539.12

3956 MONTE CARLO CALCULATIONS OF ELECTRON ENERGY LOSS. D.O.Schneider and D.V.Cormack.
Radiation Research, Vol. 11, No. 3, 418-29 (Sept., 1959).

Monte Carlo calculations of the slowing down of electrons in water, in which the slowing-down process is considered to be continuous for individual energy losses less than various "cutoff" values, are made for initial energies of 30 keV, 50 keV and 1.5 MeV to give "histories" of the primary electrons for energy "cutoff" values of 0.1 keV, 0.3 keV and 3 keV. The probability of the electron existing at various energies below the source energy, and the flux of primary electrons at a particular energy, are deduced. Except for energies close to the source energy, the primary electron flux is independent of the source energy and essentially equal to the reciprocal of total stopping power. The peak in distribution immediately below the source energy contributes less than 1% to the total energy absorption. Ranges of primary electrons are deduced for the 50 keV electrons and are plotted to show the range straggling. The average of these ranges is in good agreement with that calculated from the total stopping power.

C.B.Allsopp

539.12 : 539.11

TEST OF QUANTUM ELECTRODYNAMICS IN ELECTRON SCATTERING. See Abstr. 3916

539.12 : 539.16

POLARIZATION OF RaE ELECTRONS AND TIME REVERSAL INVARIANCE. See Abstr. 2644

539.12

3957 MEASUREMENT OF ENERGY OF ELECTRONS AND GAMMA-QUANTA WITH A COUNTER OF LOW EFFICIENCY. Yu.D.Prokoshkin and Tan Syao-Véi [T'ang Hsiao-Wei]. Pribory i Tekh Eksper., 1959, No. 3, 32-4 (May-June). In Russian.

The method is based on the measurement of the electron showers produced by high energy electrons and $\gamma$-photons passing through matter. For certain thickness ($t_0$) of the absorber the variation of mean number of shower electrons ($n_t$) with the energy of primary electrons (E) is linear. Thus, knowing this variation, the energy E can readily be obtained from the cascade curve. Different energies of positrons were determined by measuring corresponding values of $n_{t_0}$ using a set-up and method of previous work (Abstr. 12544 of 1959) in which the detector consisted of several identical halogen counters working with efficiency of about 5%, placed behind a lead absorber of thickness $t_0$. Somewhat similar method was used for determination of energy of $\gamma$-photons. J.M.Zarzycki

539.12

3958 SCATTERING OF 200 MeV POSITRONS BY ELECTRONS. J.A.Poirier, D.M.Bernstein and J.Pine. Phys. Rev., Vol. 117, No. 2, 557-65 (Jan. 15, 1960).

The scattering of positrons by electrons was investigated by bombarding a beryllium target with 200 MeV positrons and observing the recoil electrons in a diffusion cloud chamber located behind the target. The cloud chamber was in a magnetic field which permitted the yield of recoil electrons to be measured as a function of their energy W. The experiment covered the range $88 \le W \le 200$ MeV. The positron beam also traversed the cloud chamber and the total number of incident positrons was determined by track-counting. The total electron yield for $88 \le W \le 200$ MeV is $(113 \pm 9)$% below that predicted by the first-order Bhabha theory (Abstr. 1849 of 1936). This difference cannot be interpreted until radiative corrections to the theory have been evaluated. A calculation of these corrections which is valid for the conditions of this experiment is not available. The shape of the electron energy spectrum is in good agreement with the Bhabha theory, and inconsistent with the theory if annihilation terms are omitted.

539.12

3959 ANNIHILATION OF POSITRONS IN ORGANIC LIQUIDS. C.R.Hatcher, T.W.Falconer and W.E.Millett. J. chem. Phys., Vol. 32, No. 1, 28-31 (Jan., 1960).

The mean life $\tau_2$ and fraction $I_2$ of positrons which form $^3S$ positronium were measured for annihilation in 20 organic liquids—alcohols, glycols, benzene derivatives, and others. By using the measured value of $\tau_2$, it is possible to calculate $\langle \sigma v \rangle_{Av}$ where $\sigma$ is the molecular cross-section for annihilating $^3S$ positronium on collision and v is the velocity of the positronium atom. The results show that in general $\langle \sigma v \rangle_{Av}$ is related to the "size" of the molecule although there are some consistent exceptions to this rule. There is also a rough correlation between $\tau_2$ and density, $\tau_2$ being shortest for the most dense liquids and longest for the least dense ones.

539.12 : 539.2

3960 POSITRON ANNIHILATION IN METALS. S.Kahana. Phys. Rev., Vol. 117, No. 1, 123-8 (Jan. 1, 1960).

A correlation function for a positron—electron pair within a metal is obtained by solving a Bethe—Goldstone equation. Thus one may take account of the many-body effects, of screening and the exclusion principle, in computing the electron density at the position of the positron. The results indicate that one may, in this fashion, reconcile the Sommerfeld model of a metal with the experimental data on positron annihilation in metals.

539.12

3961 THE CREATION OF FAST ELECTRON PAIRS BY HIGH ENERGY MUONS. P.H.Stoker and P.C.Haarhoff. Nuclear Phys., Vol. 14, No. 3, 512-16 (Jan. [1], 1960).

The cross-sections for the creation of fast electron pairs by high-energy muons in lead are calculated, imposing a lower limit of 10 $mc^2$ on the energy of each electron of the pair.

539.12

3962 MOMENTUM DISTRIBUTION OF ANNIHILATING ELECTRON—POSITRON PAIRS IN LiF. R.H.March and A.T.Stewart. Canad. J. Phys., Vol. 37, No. 9, 1076-8 (Sept., 1959).

New measurements confirmed the results of Lang (Abstr. 1838 of 1958) and disagreed with those of Millett (Abstr. 8215 of 1958). E.J.Burge

## Nucleons

539.12

3963 NUCLEON POLARIZATION FROM CHARGE-EXCHANGE REACTIONS IN DEUTERIUM. R.J.N.Phillips. Proc. Phys. Soc., Vol. 74, Pt 5, 652-5 (Nov., 1959).

Considers polarization effects near the forward direction, due to quasi-free n—p collisions, using the impulse approximation. The exclusion principle leads to significant differences from free scattering. R.J.N.Phillips

539.12

3964 CENTRAL AND PERIPHERAL COLLISIONS BETWEEN FAST NUCLEONS. I. V.S.Barashenkov, V.M.Maltsev and E.K.Mihul. Nuclear Phys., Vol. 13, No. 4, 583-93 (Nov. (2), 1959).

About 83% of all inelastic collisions occurring at energies of 9 GeV in the examined model are collisions involving the central regions of the nucleons. For calculation of these "central collisions" methods of the statistical theory of multiple production of particles can be employed. With the exception of small angles and events in which a small number of particles participate, the data thus obtained are in good agreement with the experiments. About 17% of nucleon—nucleon collisions are peripheral collisions. Data on collisions between peripheral $\pi$-mesons and a nucleon can be obtained by using the statistical theory and experimental data on ($\pi$N) collisions at $E \ge 1$ GeV. The mean energy loss of the nucleon and mean multiplicity of the particles produced in (NN) collisions are in good agreement with the experimental data. The ratio of the number of charged particles moving forward to that of the charged particles moving backward in the c.m.s. of the colliding nucleons is close to the experimental value. Account of peripheral collisions also improves the agreement between the theoretical and experimental angular distributions of the charged particles produced in (NN) collisions.

539.12

3965 LOW ENERGY ELASTIC SCATTERING OF NUCLEONS BY DEUTERONS. S.Watanabe. Nuclear Phys., Vol. 14, No. 3, 429-37 (Jan. (1), 1960).

The elastic scattering by deuterons at low energies is discussed. The interaction forces between two nucleons include the central exchange and spin—orbit ones. The inclusion of the two-body spin—orbit force leads to a set of coupled integro-differential equations.

## Protons

539.12

3966 THE INTERACTION BETWEEN FAST NUCLEONS AND NUCLEI IN THE NIKFI-R PHOTOGRAPHIC EMULSION. V.S.Barashenkov, V.A.Belyakov, Van Shu-Fen' [Wang Shu-Fen], V.V.Glagolev, N.Dolkhazhav, L.F.Kirillova, R.M.Lebedev, V.M.Mal'tsev, P.K.Markov, K.D.Tolstov, E.N.Tsyganov, M.G.Shafranova and Yao Tsin-Se [Yao Ch'ing-Hsieh]. Atomnaya Energiya, Vol. 7, No. 4, 376-7 (1959). In Russian.

Data are tabulated concerning the effect of 9 GeV protons. The hypothesis of a cascade interaction, as against a "tube" interaction, is favoured by the low median angles of emission, the equal numbers of s particles from light and heavy nuclei, the small number of pions among the g particles, the results for disintegrations with more than 28 g and b particles, and the equality of g-proton transverse momenta for light and heavy nuclei. The average cross-section for production of $k^+$ particles of energy < 140 MeV is found to be $(5 \pm 2) \times 10^{-27}$ cm$^2$. The mean proton energy loss in collisions is 5.1 ± 0.8 GeV per nucleus (4.05 GeV of this for pion production) and 35 ± 10% per nucleon. J.B.Sykes

539.12

3967 EXCHANGE REACTION OF 90 MeV PROTONS ON DEUTERONS. D.R.Firth. Canad. J. Phys., Vol. 37, No. 9, 1074-5 (Sept., 1959).

Preliminary studies showed that this reaction can be investigated with a diffusion cloud chamber operated at a deuterium pressure of 19 atmospheres. One in every six events was due to charge exchange. E.J.Burge

539.12

### 3968 COMPLEX PHASE SHIFTS IN PROTON–PROTON SCATTERING.

R.J.N.Phillips.

uclear Phys., Vol. 14, No. 4, 633-8 (Jan. (2), 1960).

The imaginary parts of the p–p phase shifts at 380 MeV are duced from pion production data; their effect on elastic scattering pears to be negligible. Anomalies at the $\pi^+$ + d threshold are also y small.

## eutrons

539.12

### 3969 THE RELATION BETWEEN THE METHOD OF SPHERICAL HARMONICS AND THE METHOD OF DISCRETE COORDINATES.

L.Trlifaj.

zech. J. Phys., Vol. 9, No. 5, 535-43 (1959). In Russian.

The relation is studied from the point of view of the integral oltzmann equation for neutron diffusion problems which have full lane and cylindrical symmetry.

539.12

### 3970 THE MACROSCOPIC DIFFUSION OF NEUTRONS — A METHOD OF APPROXIMATION.

J.Yvon.

nuclear Energy, Vol. 4, No. 3, 305-18 (March, 1957). In French.

In the diffusion of monoenergetic neutrons the angular distribution of the velocities can be discontinuous, as in the case of neutrons rossing the boundary between a scattering medium and vacuum. In is paper a method is presented which is appropriate to this type of roblem and consists in taking from the start a different analytical xpression in the two angular regions on both sides of the discontinuity. This method is particularly suited to problems with plane ymmetry. It is tested in the case of the Milne problem.

539.12 : 530.16

NEUTRON DIFFUSION. ELEMENTARY SOLUTIONS OF THE TRANSPORT EQUATIONS. See Abstr. 3471

539.12

### 3971 THE PASSAGE OF FAST NEUTRONS THROUGH LEAD AND IRON.

D.L.Broder, A.A.Kutuzov, V.V.Levin, V.V.Orlov and A.V.Turusova.

atomnaya Energiya, Vol. 7, No. 4, 313-20 (1959). In Russian.

Results are given of measurements of the spatial distribution in ead and iron of fast neutrons from sources of energies E = 4 and 4.9 MeV and of reactor neutrons. A method of solving the Boltzmann equation in media which slow down neutrons by inelastic collisions with nuclei has been developed in order to calculate the space and energy distribution of fast neutrons at large distances from the source. The anisotropy of elastic scattering is taken into account, but the loss of neutron energy in elastic scattering is neglected.

J.B.Sykes

539.12

### 3972 THE SLOWING DOWN OF FISSION NEUTRONS IN WATER.

L.M:Barkov and K.N.Mukhin.

J. nuclear Energy, Vol. 4, No. 1, 91-3 (Jan., 1957). English translation of article in: Atomnaya Energiya, Vol. 4, No. 1, 31 (1956).

$\tau$ has been measured for $U^{235}$ fission neutrons, slowed down to 1.46 eV in water. The result is $\tau$(1.46 eV neutrons) = 29.4 ± 1.5 cm$^2$.

539.12

### 3973 MEASUREMENT OF THE SLOWING DOWN OF NEUTRONS IN THE ENERGY RANGE 1.46-0.025 eV IN WATER.

L.M.Barkov, V.K.Makarin and K.N.Mukhin.

J. nuclear Energy, Vol. 4, No. 1, 94-102 (Jan., 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 3, (1956).

Photoneutrons from a Sb + Be source were slowed down in water and the resulting distribution of resonance ($E_B$ = 1.46 eV) and thermal neutrons was measured with an indium detector. The age $\tau$(for 1.46 eV neutrons) was determined, also the diffusion length of thermal neutrons in water and the mean square slowing-down length $\Delta\tau$ from 1.46 eV to thermal energies (0.025 eV).

539.12

### 3974 THE SLOWING DOWN OF FISSION NEUTRONS IN URANIUM-WATER MEDIA.

L.M.Barkov, A.P.Venediktov and K.N.Mukhin.

J. nuclear Energy, Vol. 4, No. 1, 103-8 (Jan., 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 3, 40 (1956).

The density distribution of resonance neutrons (E = 1.46 eV), originating from a point source of $U^{235}$ fission neutrons, has been measured in three different uranium-water lattices. The uranium was in the form of thick rods (35 mm) of the natural element sheathed in cadmium. It was shown that there was no anisotropy in the neutron distribution, and the value of $\tau$ was determined.

539.12

### 3975 ON THE DETERMINATION OF THE SLOWING DOWN LENGTH IN ORDINARY WATER USING A PULSED NEUTRON SOURCE.

R.Ramanna and M.P.Navalkar.

Proc. Indian Acad. Sci. A, Vol. 45, No. 2, 74-83 (Feb., 1957).

Two-group theory shows that the slowing down length can be determined from a measurement of the spatial distribution of pulsed thermal neutrons. These were produced by 19 $\mu$sec pulses of deuterons on a beryllium target which was in a Perspex, cadmium lined tank filled with water. Thermal neutrons were detected by a lithium iodide scintillation counter. Decay constants calculated from graphs of $\log\rho_S(r,t)$ against time at various radii, by a corrected Marshak's formula for the age of thermal neutrons and two-group theory, are independent of radius and in agreement with an earlier value. The age of thermal neutrons, calculated from a graph of $\log(r^2\rho_S(r,t)/S_0)$ against radius, was found to be 41.05 ± 1.64 cm$^2$.

D.H.Lord

539.12 : 539.17

SPECTRA OF FISSION NEUTRONS. See Abstr.2691

539.12 : 539.17

RELATIVE YIELDS OF DELAYED NEUTRONS IN FISSION OF $U^{238}$, $U^{235}$, AND $Th^{232}$. See Abstr.2694.

539.12 : 539.14

### 3976 MEASUREMENT OF SOME NEUTRON SPECTRA BY THE NUCLEAR EMULSION METHOD.

L.Drška, I.Chudáček and F.Štěrba.

Czech. J. Phys., Vol. 8, No. 6, 648-57 (1958). In Russian with summary (2 pp.) in English.

Presents the results of measurements of the neutron spectra of two fast neutron sources, viz. Ra + Be and a thick Li target bombarded by deuterons. The spectra obtained were used for the determination of the $Be^8$ energy levels.

F.Lachman

## Mesons

539.12 : 539.18

### 3977 SCHWINGER'S MESON AND THE $\mu$-MESIC ATOM.

I.R.Gatland.

Nuclear Phys., Vol. 14, No. 2, 205-11 (Dec. [2], 1959).

The properties of Schwinger's meson ($\sigma$) which is supposed to interact with muons and cascade particles, was estimated by calculating (i) the muon self-mass and comparing this with the muon–electron mass difference, (ii) the anomalous effect on the bound-state levels of $\mu$-mesic atoms and comparing this with the experimental data. These and other results were used to obtain values of the $\sigma$-meson mass and the strength of its coupling to muons and baryons.

539.12

### 3978 INVESTIGATION OF PARITY CONSERVATION IN STRONG INTERACTIONS AT HIGH ENERGIES.

V.G.Solov'ev.

Dokl. Akad. Nauk SSSR, Vol. 129, No. 1, 68-71 (Nov. 1, 1959). In Russian..

The nonconservation of parity in strong interactions can be examined by observing the distributions of the final state particles when three or more are produced in some collision process. The nonconservation should show up as asymmetries in the distribution with respect to planes defined by two independent momenta. The choice of reactions which are suitable for searching for possible parity violation in processes involving strange particles is examined in detail.

R.F.Peierls

539.12

### 3979 A NEW MODEL FOR MULTIPLE MESON PRODUCTION AT HIGH ENERGIES.

W.Czyz, T.Ericson and S.L.Glashow.

Nuclear Phys., Vol. 13, No. 4, 516-24 (Nov. (2), 1959).

A new approach to the multiple meson production process is proposed, which is based upon the peripheral nature and energy-independent behaviour of high-energy nucleon–nucleon collisions. A specific model suggested by the analogy with Cherenkov radiation is described.

539.12

### 3980 EXPERIMENTAL INVESTIGATION ON THE ANGULAR DISTRIBUTION OF ELECTRONS FROM $\mu$-MESON DECAY.

M.Friml.

Czech. J. Phys., Vol. 9, No. 5, 552-6 (1959) In Russian.

A description is given of the measurement of the angular distribution. The results confirm that the angular distribution is asymmetrical, as required by the hypothesis of parity nonconservation in weak interactions of elementary particles. The asymmetry of the measured electron distribution is discussed.

539.12 : 539.18

### 3981 ON IONIC REACTIONS OF NEGATIVE $\mu$-MESONS.

P.G.Burke, F.Haas and I.C.Percival.

Proc. Phys. Soc., Vol. 73, Pt 6, 912-23 (June, 1959).

The threshold rate coefficient for the $\mu$-exchange process $p\mu + d^+ \rightarrow d\mu + p^+$ is calculated taking into account the effects of strong coupling and of reduced masses. The result is smaller by a factor of about 100 than weak coupling approximations, but is still consistent with experiment.

539.12

### 3982 LARGE-ANGLE SCATTERING OF FAST $\mu$ MESONS.

J.L.Lloyd and A.W.Wolfendale.

Phys. Rev., Vol. 117, No. 1, 247-9 (Jan. 1, 1960).

Experiments on cosmic-ray $\mu$-mesons over the past seven years have appeared to show "anomalous" scattering. This anomaly is a small excess of large-angle scattering over that expected on current nuclear models. A recent experiment by Fukui, Kitamura, and Watase (Abstr. 4927 of 1959) has failed to show anomaly. Here the data given by Fukui et al. are re-examined and it is shown that their experiment is inconclusive.

539.12 : 539.18

### DETERMINATION OF FREE MUON POLARIZATION USING MU-MESONIC ATOMS. See Abstr. 2718

539.12

### 3983 SEARCH FOR $\pi_{10}{}^0 \rightarrow 3\gamma$.

R.P.Ely and D.H.Frisch.

Phys. Rev. Letters, Vol. 3, No. 12, 565-7 (Dec. 15, 1959).

A thin Li target was bombarded with 160 MeV protons from the Harvard cyclotron. $\gamma$-rays were detected by three high-Z energy-sensitive Cherenkov counters. The angles between the counters and the beam were chosen so that detection of ordinary $\pi^0 \rightarrow 2\gamma$ by double coincidence is kinematically forbidden while double coincidence from $\pi_{10}{}^0 \rightarrow 3\gamma$ may occur. After subtracting background a differential production cross-section $(2 \pm 1) \times 10^{-33}$ cm$^2$ sterad$^{-1}$ nucleon$^{-1}$ was found. Ideas for a confirmatory experiment are discussed. R.H.W.Johnston

539.12

### 3984 HIGH ENERGY TOTAL CROSS SECTIONS FOR POSITIVE PIONS AND PROTONS ON HYDROGEN.

M.J.Longo, J.A.Helland, W.N.Hess, B.J.Moyer and V.Perez-Mendez.

Phys. Rev. Letters, Vol. 3, No. 12, 568-70 (Dec. 15, 1959).

Total cross-sections for the interaction of $\pi^+$ mesons and of protons with hydrogen were measured in the momentum range 1.4 - 4.0 GeV/c. A beam of positive particles of momentum defined to within 3%, was scattered in a liquid hydrogen target, using a transmission method. Positive pions were distinguished from protons by including in the counter system a gas Cherenkov detector. The results are generally more accurate than previous ones, and are so far the only measurements for $\pi^+$ above 2 GeV/c. The $\pi^+$ cross-section seems to approach a constant value of 29.3 ± 0.4 mb above 2.5 GeV/c. The best high energy results for $\pi^-$–p scattering give 28.7 ± 2.6 mb at 4.3 GeV/c. This seems to agree with a theorem due to Pomeranchuk (Abstr.8219 of 1958), based on dispersion relations, according to which, if each of these cross-sections approaches a constant value at high energies, these values should be equal. S.J.Goldsack

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### 3985 MESON–NUCLEON SCATTERING AND NUCLEAR FORCES.

V.F.Weisskopf.

Phys. Rev., Vol. 116, No. 6, 1615-17 (Dec. 15, 1959).

A simple derivation which does not make use of field theory is given of the main results of the static theory of $\pi$-meson scattering by nucleons. The derivation serves to elucidate the connection between low-energy meson scattering and the nuclear forces at large distances.

539.12

### 3986 PION–PROTON SCATTERING BELOW 150 MeV. I.

S.W.Barnes, B.Rose, G.Giacomelli, J.Ring, K.Miyake and K.Kinsey.

Phys. Rev., Vol. 117, No. 1, 226-37 (Jan. 1, 1960).

$\pi^+$–proton differential cross-sections were measured at 41.5 MeV for six angles. The angles in the centre-of-mass system were 53°, 69.1°, 100.4°, 128°, 141.7° and 163.5° and the corresponding cross-sections in mb/sterad in the centre-of-mass system are 0.252 ± 0.020, 0.354 ± 0.025, 0.777 ± 0.038, 1.145 ± 0.067, 1.495 ± 0.084, and 1.750 ± 0.110. $\pi^-$ elastic cross-sections were measured for the first five of the above angles and are, respectively, in mb/sterad in the c.m. system: 0.338 ± 0.047, 0.281 ± 0.038, 0.148 ± 0.029, 0.112 ± 0.042, and 0.085 ± 0.25. Phase-shift analyses of these data and those of other authors lead to the following expressions for the low-energy behaviour of the $T = \frac{3}{2}$ phases: $\alpha_{31}{}^N = -(0.0418 \pm 0.004)\eta^3$, $\alpha_3{}^N = -(0.1145 \pm 0.0026)\eta$, and

$$\cot \alpha_{33}{}^N = \tfrac{4}{3}\eta^3 (0.0877 \pm 0.0014)/[\omega^*(1 - \omega^*/2.17)].$$

539.12

### 3987 PION–PROTON SCATTERING BELOW 150 MeV. II.

S.W.Barnes, H.Winick, K.Miyake and K.Kinsey.

Phys. Rev., Vol. 117, No. 1, 238-42 (Jan. 1, 1960).

Values found for 30 MeV scattering at the two centre-of-mass angles 116.8° and 155° are, respectively, for $\pi^+$: 0.849 ± 0.048 and 1.098 ± 0.075 mb/sterad; and for $\pi^-$ of the same energy: 0.187 ± 0.020 and 0.165 ± 0.022 mb/sterad. Phase-shift analyses are made of recent published $\pi^-$ distributions in the above energy range and serve to furnish prescriptions for the low-energy behaviour of the $T = \frac{1}{2}$ phases. Calculations of $\sigma^{--}$, $\sigma^{-0}$, and $\sigma_{\text{total}}{}^-$ at various energies agree with measurements found in the literature. An essential agreement is found between $\pi^- + p$ forward scattering amplitudes and a dispersion equation over this energy region.

539.12

### 3988 $\pi^\pm$–p ELASTIC SCATTERING AT 30 MeV.

G.Giacomelli.

Phys. Rev., Vol. 117, No. 1, 250-1 (Jan. 1, 1960).

Differential scattering cross-sections in hydrogen for (30 ± 1.5) MeV $\pi^+$ and $\pi^-$ were measured at the two centre-of-mass angles of 82° and 99.9°. The cross-sections for $\pi^+$ in mb/sterad in the centre-of-mass system are 0.435 ± 0.028 and 0.590 ± 0.030; for $\pi^-$, 0.268 ± 0.028 and 0.239 ± 0.021, respectively.

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### 3989 MEASUREMENTS OF THE $\pi^\pm$–p TOTAL SCATTERING CROSS SECTIONS IN THE ENERGY RANGE 0.4 to 1.5 BeV.

J.C.Brisson, J.Detoef, P.Falk-Vairant, L. van Rossum, G.Valladas and L.C.L.Yuan.

Phys. Rev. Letters, Vol. 3, No. 12, 561-3 (Dec. 15, 1959).

This experiment makes use of $\pi^\pm$ beams of mean energy known to 1% and with ± 1.8% energy spread. In all, 23 absorption measurements were made at suitably spaced energy intervals. Well-defined maxima in the $\pi^-$–p curve occurred at ~ 600 MeV and ~ 800 MeV ($\pi^-$ laboratory energy). The ~ 600 MeV maximum is in approximate agreement with the 570 MeV (c. of m.) $\pi$-nucleon resonance state suggested by photo-production work (Abstr. 6171 of 1958). R.H.W.Johnston

539.12

### 3990 POSITIVE PION SCATTERING FROM HYDROGEN AT 24.8 MeV.

D.Miller and J.Ring.

Phys. Rev., Vol. 117, No. 2, 582-4 (Jan. 15, 1960).

An angular distribution for the process $\pi^+ + p \rightarrow \pi^+ + p$ was measured at 24.8 MeV by counter techniques. At this energy the S-wave interaction is larger than the P wave. Differential cross-sections at the three centre-of-mass angles, 66°, 92°, and 163.5°, are (0.286±0.028), (0.458±0.042) and (0.993±0.120) mb/sterad, respectively. Over 250 hydrogen interactions were observed at each angle.

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### 3991 THE ELASTIC SCATTERING OF 98 MeV NEGATIVE PIONS BY HYDROGEN.

N.Edwards, S.G.F.Frank and J.R.Holt.
Proc. Phys. Soc., Vol. 73, Pt 6, 856-68 (June, 1959).

The elastic scattering was measured at 13 angles between 30° and 150° (lab.). The pion beam was monitored with a calibrated ionization chamber and its muon and electron contamination determined by means of a Cherenkov counter. This counter was also used in the scattering telescope to separate out the electrons produced by charge exchange $\gamma$-radiation. The results were corrected for Coulomb effects and a 3-parameter curve fitted to the nuclear parts. The curve is

$$d\sigma/d\Omega = (1 \pm 0.027)\,[0.385 \pm 0.008 + (0.276 \pm 0.015)\cos\theta + (0.282 \pm 0.031)\cos^2\theta].$$

Thus the forward scattering intensity is 0.942 ± 0.043 mb $\text{sterad}^{-1}$. In a separate transmission experiment the total nuclear cross-section for scattering of 98 MeV negative pions by hydrogen was found to be 21.9 ± 0.7 mb. These two figures yield a value for the real part of the forward scattering amplitude $D_- = 0.195 \pm 0.006$ in units $\hbar/m_\pi c$. The corresponding value of $f^2$ from the dispersion relation is 0.073.

539.12

### 3992 A FIELD-THEORETICAL GENERALIZATION OF THE IMPULSE APPROXIMATION. F.Kaschluhn.

Nuclear Phys., Vol. 14, No. 2, 314-38 (Dec. (2), 1959). In German.

A generalization of Chew's impulse approximation in field theory is proposed, which may be used for an explicit evaluation of the contribution from the non-observable region in the dispersion relations for pion—deuteron scattering. The Hamiltonian formalism for a non-relativistic two-nucleon system is assumed with a pseudo-vector coupling to the pion field for which the usual cut-off is used. The generalization to the case of more than two nucleons and to other couplings is obvious, and it should also be possible, with appropriate modifications, to extend the method to the relativistic case. The time-dependent scattering formalism is employed: the S-matrix describes transitions between the bare states of the two-nucleon system, which are defined as the projections of the corresponding real states on to the meson vacuum. This leads directly to the introduction of a field-energy operator which involves self-energies and interaction between the nucleons, and by means of which it is possible to avoid the difficulties associated in general with the bound state problem in quantum field theory. It is shown that the higher approximations to the impulse approximation correspond, also in field theory, to the potential scattering and multiple scattering corrections, which also include the absorption phenomena.

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### 3993 POSSIBLE RESONANCES IN $\pi$—$\pi$ SCATTERING.
Hu Ning.

Science Record (China), New Series, Vol. 3, No. 11, 550-6 (Nov., 1959).

Discusses the $\pi$—$\pi$ scattering amplitude in terms of conventional field theory and Feynman diagrams. A simple form is assumed for the contribution of basic $\pi$—$\pi$ scattering diagrams, and all iterations of the latter are included. Conditions for a resonance to exist are investigated. R.J.N.Phillips

539.12

### 3994 PHOTOPRODUCTION OF NEUTRAL PIONS AT ENERGIES 600 TO 800 MeV. R.M.Worlock.

Phys. Rev., Vol. 117, No. 2, 537-43 (Jan. 15, 1960).

The photoproduction of neutral $\pi$-mesons from hydrogen was studied by detecting recoil protons from a liquid hydrogen target irradiated by a synchrotron bremsstrahlung beam. The recoil protons were detected by a five-counter telescope. Data were taken at proton laboratory angles of 19°, 30°, 40°, 50° and 60° at proton energies corresponding to photon energies of 600, 700 and 800 MeV. Angular distribution data are produced at these three energies and fitted with functions of the form: $A + B\cos\theta'_\pi + C\cos^2\theta'_\pi$. These functions are qualitatively like those at lower energies; B is small and -A/C is roughly 1.25. The total cross-section is found to have a minimum at about 600 MeV, being slightly larger at 700 and 800 MeV.

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### 3995 POSITIVE PION PHOTOPRODUCTION NEAR THRESHOLD. G.Jona-Lasinio and H.Munczek.

Phys. Rev., Vol. 117, No. 2, 585-9 (Jan. 15, 1960).

An investigation is made in order to test the compatibility of photoproduction data on positive pions near threshold with some predictions of dispersion theory. The result is that no real disagreement necessarily exists between these theoretical predictions and the still uncertain experimental knowledge.

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### 3996 ON THE MEASUREMENT OF $\pi^+$ MESON PHOTOPRODUCTION FROM HYDROGEN NEAR THRESHOLD.
G.M.Lewis and R.E.Azuma.

Proc. Phys. Soc., Vol. 73, Pt 6, 873-80 (June, 1959).

A new counter method was developed for measuring $\pi^+$-meson photoproduction near threshold. It was employed, in partcular, to examine the variation with energy of the differential cross-section from hydrogen, at laboratory angles of 115° and 90° to the gamma-ray beam of the Glasgow synchrotron. Polythene and carbon targets were used. Results are compared with theory and an assessment can be made of the matrix element in the gamma-ray range 165-190 MeV. Values of absolute cross-section at various energies were also obtained, e.g. for an angle of 90° and a gamma-ray energy of 170 MeV, the absolute differential cross-section in centre-of-mass coordinates is $(0.48 \pm 0.11) \times 10^{-29}\ \text{cm}^2$ per steradian. The measurements also confirm the generally accepted value of the $\pi^+$ meson lifetime.

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### 3997 FERMI'S THEORY OF MULTIPLE PION PRODUCTION AND THE ZERO-POINT ENERGY. K.K.Singh.

Proc. Nat. Inst. Sci. India A, Vol. 21, No. 4, 252-8 (July 26, 1955).

Fermi's statistical theory of multiple pion production is extended to the case of a nucleon—nucleus collision, taking into account the zero-point energy of the pions. Numerical calculations of the relative probabilities are made. It is seen that the introduction of the zero-point energy substantially reduces the number of pions produced. Fermi's estimate of the number of pions produced on the basis of statistical thermodynamics is shown to have appreciable error.

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THE UNIVERSAL FERMI INTERACTION AND HEAVY MESONS. See Abstr. 3927

539.12

### 3998 THE THREE-BODY K-MESON DECAY.
J.Nilsson.

Nuclear Phys., Vol. 14, No. 4, 639-47 (Jan. (2), 1960).

A method for calculation of polarization states of relativistic Dirac fields is given and applied to the three-body K-meson decay. The matrix elements for these processes are given the most general form compatible with a V—A interaction and relativistic invariance. As a consequence, the final expression for the transition probabilities includes two unknown functions to be determined from the experimental material. The analysis of the results available from different sources is still found insufficient for definite conclusions regarding the type of interaction. New possible tests of the V—A theory are proposed.

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### 3999 LOW-TYPE INTEGRAL EQUATIONS FOR THE ABSORPTION AND PRODUCTION OF K MESONS.
S.Barshay.

Nuclear Phys., Vol. 13, No. 3, 435-46 (Nov. (1), 1959).

A discussion is given of Low-type integral equations for approximate transition amplitudes which describe the processes $\bar{K} + N \to \pi + Y$ and $\pi + N \to K + Y$. Isobaric spin and angular momentum decompositions of the equations are performed, and the resulting sets of integral equations for the various amplitudes are discussed with nonrelativistic approximations for the interaction current operators. Certain assumptions are made with regard to the as yet unknown relative parities, coupling strengths, and scattering properties of the strange particles, in a preliminary effort to utilize the field equations as a model for correlating certain features of the present experimental data on the absorption of low-energy $K^-$ mesons by protons.

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### 4000 $K^+$—DEUTERIUM INELASTIC AND EXCHANGE SCATTERING. II. M.Gourdin and A.Martin.

Nuovo Cimento, Vol. 14, No. 4, 722-34 (Nov. 1, 1959).

Modifications of previous calculations (Abstr. 9991 of 1959) to include the interaction of the nucleons in the final state when the deuteron is dissociated. The total cross-sections are only slightly modified but the differential cross-sections are sensitive to the final state interaction. It is suggested that measurements of the ratio of charge exchange to non-charge exchange scattering would give information about the T = 0 scattering amplitude. C.J.Batty

539.12

4001 K-MESON PRODUCTION IN $\pi$–p COLLISIONS AND K-MESON PARITY. V.Gupta.

Nuclear Phys., Vol. 14, No. 4, 626-32 (Jan. (2), 1960).

The reactions $\pi^+ \to p + K^+ + \bar{K}^0$ and $\pi\ + p \to p + K^- + K^0$ are considered and numerical values of the differential cross-sections given. The calculations were done with a two-fold purpose: (i) on the Gell-Mann coupling scheme, with the hope of deciding between the two cases of even and odd relative K–N parity, and (ii) on the recent suggestion of a $KK\pi$-interaction by Pais (requiring odd $K^+$–$K^0$ relative parity) with a view to testing its existence.

**Hyperons**

539.12

4002 THE LIFETIME OF THE $\Sigma^+$-HYPERON. M.F.Kaplon, A.C.Melissinos and T.Yamanouchi.

Ann. Phys. (New York), Vol. 9, No. 1, 139-68 (Jan., 1960).

The apparent discrepancy in the lifetime of the $\Sigma$-hyperons in emulsions has been investigated by using the $\Sigma^+ \to p + \pi^0$ decay mode. The method of maximum likelihood was used and a detailed description of its applications and limitations is given. Results of Monto Carlo calculations performed to test the consistency of the method are reported and are in complete agreement with the theoretical predictions. By combining data from three laboratories, a sample of 131 events decaying both in flight and at rest is formed. Estimates of the lifetime obtained by using decays in flight only and both the latter and decays at rest yield different results: this difference is statistically significant. However, the hypothesis of a double lifetime is not substantiated by the data and is rejected. Comparison with bubble chamber data is also made and it is concluded that the best value for the $\Sigma^+$-hyperon lifetime is $\tau = (0.70 \pm 0.15) \times 10^{-10}$ sec. Detailed data, on 130 charged $\Sigma$-hyperons are presented in five tables.

539.12

4003 NEUTRAL BRANCHING RATIOS OF $\Lambda$ AND $K^0$ PARTICLES. J.L.Brown, H.C.Bryant, R.A.Burnstein, D.A.Glaser, R.W.Hartung, J.A.Kadyk, D.Sinclair, G.H.Trilling, J.C. Vander Velde and J.D.van Putten.

Phys. Rev. Letters, Vol. 3, No. 12, 563-5 (Dec. 15, 1959).

The ratio of the neutral to the charged decay modes of $\Lambda$ and $K^0$ particles has been measured directly in a xenon bubble chamber. The values are in agreement with the prediction of the $\Delta I = \frac{1}{2}$ rule for the $\Lambda$ decay, and with the prediction of $\Delta I = \frac{1}{2}$ together with a slight admixture of $\Delta I = \frac{3}{2}$ (to account for the $K^+ \to \pi^+ + \pi^0$ decay) for the $K^0$ decay. The probabilities of the $\Lambda$ decaying into a pion plus a nucleon, and the $K^0$ into two pions were also found in this experiment. The results are approximately one in the first case and one-half in the second as expected. E.J.Squires

539.12

4004 PARITY NONCONSERVATION IN HYPERON DECAYS. F.E.Prieto.

Nuclear Phys., Vol. 13, No. 3, 456-60 (Nov. (1), 1959).

The suggestion made by Tati (1958), relating parity conservation or nonconservation to the type of particles involved in the weak interaction vertex responsible for the decay, is examined in the framework of d'Espagnat and Prentki's formalism for strong and weak interactions. It is found that, as long as one considers only second-order effects, the results are in reasonable agreement with the available experimental data, but that, if higher order corrections are considered, serious discrepancies are found with the experimental data on parity nonconservation for the $\Lambda$ and $\Sigma^-$ decays into a charged pion and a nucleon.

**Alpha-particles**

539.12

4005 ALPHA–ALPHA SCATTERING IN THE ENERGY RANGE 5 TO 9 MeV. C.M.Jones, G.C.Phillips and P.D.Miller.

Phys. Rev., Vol. 117, No. 2, 525-30 (Jan. 15, 1960).

The scattering of alpha particles from helium was studied by the measurement of three excitation functions at the centre-of-mass angles 30° 33′, 54° 44′, and 70° 7′. A phase-shift analysis was performed which indicates that only the S- and D-wave phase shifts are necessary to fit the data in this energy region. Only the well-known D state at approximately 2.9 MeV in $Be^8$ was observed. The D state was compared to the single-level dispersion theory and level parameters were extracted which are compatible with the alpha-particle model of $Be^8$.

539.12

4006 ALPHA–ALPHA SCATTERING AT 7.56 MeV. N.Berk, F.E.Steigert and G.L.Salinger.

Phys. Rev., Vol. 117, No. 2, 531 (Jan. 15, 1960).

Alpha particles scattered from a helium gas target were observed in nuclear emulsions. The differential cross-sections measured can be fitted with phase shifts of $\delta_0 = 70^\circ$ and $\delta_2 = 100^\circ$.

## COSMIC RAYS

*(Nuclear reactions due to cosmic rays are included under Nuclear Reactions)*

537.59

4007 COSMIC RADIATION. L.Scarsi.

Amer. J. Phys., Vol. 28, No. 3, 213-20 (March, 1960).

The paper gives some general information about cosmic rays, especially with regard to the properties of the primary flux: charge composition, energy spectrum, and time variations. The experimental evidence for these properties of the cosmic rays is outlined briefly and possible origins of the radiation are discussed.

537.59

4008 THE ORIGIN OF COSMIC RAYS. L.Davis, Jr.

Nuovo Cimento Suppl., Vol. 13, No. 1, 324-9 (1959).

Some of the important observed properties of cosmic rays are summarized, and their mechanism of origin is considered. A model is proposed in which most of the cosmic rays were accelerated in the early stages of evolution of the galaxy. These would then be stored in the galactic halo thereby playing an important part in its structure. A.H.Gabriel

537.59

4009 LOW-ENERGY $\pi$ MESONS IN THE COSMIC RADIATION. M.Fotino.

Phys. Rev., Vol. 117, No. 1, 243-8 (Jan. 1, 1960).

The intensity of $\pi$-mesons in the atmosphere was investigated in the kinetic energy region $E < \sim 50$ MeV at sea level and at mountain altitudes. $\pi^+$-mesons coming to rest in an absorber-scintillator were identified by the characteristic $\pi$–$\mu$ decay. They were detected electronically and recorded photographically. The value 1.45 ± 0.09 was adopted for the negative-to-positive ratio at small energies. The omnidirectional intensities $J_{\pi^+}$ of slow $\pi^+$-mesons at sea level (91m), Echo Lake, Colorado (3260 m), and Mt. Evans, Colorado (4310 m) are found to be $0.0094 \pm 0.0024$, $0.098 \pm 0.005$, and $0.240 \pm 0.011$ g$^{-1}$ day$^{-1}$, respectively. The altitude dependence of $J_\pi{}^\pm$, $J_\mu{}^\pm$ and $J_\pi{}^\pm/J_\mu{}^\pm$ is given and the attenuation length of slow $\pi$-mesons in the atmosphere found to be $L_a{}^\pi \cong 120\text{-}130$ g/cm$^2$ in this altitude interval. A discussion covering most of the available results along the same line is presented.

537.59

4010 CHANGES IN THE DIFFERENTIAL RIGIDITY SPECTRUM OF PRIMARY COSMIC RAYS ASSOCIATED WITH LONG-TERM AND SHORT-TERM INTENSITY VARIATIONS. J.R.Storey.

Phys. Rev., Vol. 117, No. 2, 573-7 (Jan. 15, 1960).

For previous work, see Abstr.4767-8 (1959). During June and July, 1958, the cosmic-ray nucleonic component was surveyed along the geographic longitude 147.5°E between geographic latitudes 10°S and 44°S ($\lambda$ = 10°S and 53°S) at atmospheric depth 475 g cm$^{-2}$ with a neutron monitor mounted in an aircraft. This route is substantially e same as one covered during similar surveys in July and August, 57. The data have been analysed to yield long-term and short-rm changes in the differential rigidity spectrum j(N), for N in the nge 2.0 to 9.0 BV. A power law, $\Delta j(N) \propto N^{-\beta} j(N)$, with $\beta = 1.3$, fits e observations for the long-term change between July, 1957 and ly, 1958. For a single short-term variation in 1958 the value = 1.2 was obtained, with evidence that $\beta$ decreases at higher rigid-es. (N>7.0 BV) A 1.5° northward shift of the south latitude knee tween the two series of flights is reported. Finally, high-latitude tensity variations of the nucleonic component at 475 g cm$^{-2}$ are mpared with variations observed with a neutron monitor at Hobart = 52°, 950 g cm$^{-2}$). A 1.0% change in intensity at Hobart is equi-lent to a 1.8±0.3% change at 475 g cm$^{-2}$, independently of the time ale of the variations.

# NUCLEUS

539.14

## 4011 SUPERFLUIDITY AND THE MOMENTS OF INERTIA OF NUCLEI. A.B.Migdal.

uclear Phys., Vol. 13, No. 5, 655-74 (Nov. [3], 1959).

A method is presented which permits one to study superfluidity a finite size systems. Moments of inertia are computed by this ethod in the quasi-classical approximation and satisfactory agree-ent with the observed values is obtained. The calculated increase f the moment of inertia upon transition from even to odd-mass clei and also the gyromagnetic ratio for rotating nuclei are in greement with the experiments. These results thus confirm the ssumption of superfluidity of nuclear matter.

539.14

## 4012 ANTISYMMETRIZATION OF "CLUSTER MODEL" WAVE FUNCTIONS AND THEIR EXPANSION IN "SHELL ODEL" WAVE FUNCTIONS. T.Kanellopoulos and K.Wildermuth.

uclear Phys., Vol. 14, No. 3, 349-75 (Jan. (1), 1960).

A method is described whereby oscillator "cluster model" wave-nctions may be antisymmetrized and expressed as a superposition f "shell model" wave-functions. Moreover, some ideas are pre-ented concerning the antisymmetrization of wave-functions in eneral. For the cluster model calculations, they are useful when assing from the oscillator wave-functions to more general cluster ave-functions.

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## 4013 APPLICATION OF THE COLLECTIVE MODEL TO SOME NUCLEI IN THE d-SHELL. G.R.Bishop.

Nuclear Phys., Vol. 14, No. 3, 376-88 (Jan. (1), 1960).

Eigenvalues and eigenfunctions were recalculated for the Nilsson deformed potential well with the addition of a term $\mu l^2$. Comparison of the results with the decay schemes of nuclei in the d-shell shows that some of the existing discrepancies are removed by the presence of this correction to the oscillator potential dependent on the orbital angular momentum.

539.14

## 4014 STABILITY OF NUCLEAR MATTER. K.Sawada and R.M.Rockmore.

Phys. Rev., Vol. 116, No. 6, 1618-19 (Dec. 15, 1959).

The stability condition for a model of collective excitations of nuclear matter due to Glassgold, Heckrotte, and Watson (Abstr. 4970 of 1959) is derived; it is shown that it may be satisfied for the actual parameters (nuclear radius, strength of potential, etc.). It is possible that nuclear matter is stable in their approximation, although there is no compressional collective mode. The stability condition seems to imply values of $\eta$, the radius parameter used by Karplus and Watson (Abstr. 4225 of 1958), equal to or smaller than those values obtained from their simple saturating nuclear model.

539.14

## 4015 ROLE OF SPIN—ORBIT FORCE IN NUCLEAR INTERACTIONS. A.N.Mitra and V.L.Narasimham.

Nuclear Phys., Vol. 14, No. 3, 406-28 (Jan. (1), 1960).

The two-body problem (scattering and bound state) was solved exactly by considering an extension of Yamaguchi's non-local separable potential so as to include a two-body spin—orbit force. The parameters of the potential were determined by obtaining their exact relationships with the low-energy experimental data (scattering length, effective range, deuteron binding energy, quadrupole and magnetic moments and the D-state probability). It is found that in order to fit the data, particularly the magnetic moment, the strength of the spin—orbit force must be comparable to that of the tensor force. This potential was applied to the evaluation of the spin—orbit energy splitting in the nuclei $Ca^{41}$ and $O^{17}$. It is found that the tensor force by itself gives the wrong sign of the splitting and that it is overcompensated by a large contribution (of the correct sign) arising from the two-body spin—orbit force.

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## 4016 THEORETICAL CALCULATION OF THE BINDING ENERGY OF $O^{16}$. P.Goldhammer.

Phys. Rev., Vol. 116, No. 3, 676 (Nov. 1, 1959).

The second-order perturbation procedure of Bolsterli and Feenberg (Abstr. 3095 of 1956) is applied to the ground state of $O^{16}$. The two-body interaction operator employed has a Serber exchange character with repulsive core and tensor component, determined to give a reasonable fit to the properties of $H^2$, $H^3$, $He^3$, and $He^4$ to the accuracy of the perturbation procedure. The resulting eigenstate for $O^{16}$ is found to have energy eigenvalue $-129.2$ MeV and r.m.s. radius $2.33 \times 10^{-13}$ cm. Coulomb forces are neglected. Components in the wave-function different from the zero-order shell-model state are found to have a statistical weight of about 18%.

539.14

## 4017 LINEAR RELATIONSHIPS CONNECTING SOME NUCLEON SEPARATION ENERGIES AND THE MASS NUMBER. F.Everling.

Z. Naturforsch., Vol. 14a, No. 9, 787-90 (Sept., 1959). In German.

The nucleon separation energies $S_n$ and $S_p$ are calculated as a function of the mass number for the ground state and the low excited states of mirror nuclei with mass numbers A = 4n + 1 in the range $17 \leq A \leq 29$. It is found that the line for $S_{n,p}$, the separation energy of a neutron and a proton in even-even nuclei approximates closely to the mean value of $S_n$ and $S_p$. The assumption of a $\frac{1}{2} A^{2/3}$ dependence of $S_n$ distorts the linear relation. It is concluded that the parameter $S_n - S_p$ for $J^\pi = \frac{1}{2}^+$ states is linearly dependent on A, rather than on than on $A^{2/3}$. S.J.St-Lorant

539.14

## 4018 ZERO SPIN OF THE 1265 keV STATE IN $Pt^{194}$. M.W.Johns and J.D.MacArthur.

Canad. J. Phys., Vol. 37, No. 10, 1205-6 (Oct., 1959).

Angular correlation measurements of two $\gamma$-ray cascades from the 1265 keV level in $Pt^{194}$, through the levels at 328 and 621 keV respectively, have established the spin of the 1265 keV level as zero and presumably, even parity. The spin sequence of levels in $Pt^{194}$ is therefore $0^+$, $2^+$, $2^+$, $0^+$, and is the same as in $Os^{188}$. The $Pt^{194}$ levels were excited by $\beta$-decay of $Ir^{194}$ produced by thermal neutron irradiation of enriched $Ir^{193}$ in a reactor. R.E.Meads

539.14

## 4019 COLLECTIVE VIBRATIONS OF CLOSED-SHELL NUCLEI. J.M.Araújo.

Nuclear Phys., Vol. 13, No. 3, 360-81 (Nov. (1), 1959).

Collective vibrations in atomic nuclei are studied, assuming a time-dependent nuclear well potential. The collective frequencies (and the collective parameters $B_\lambda$ and $C_\lambda$) are obtained by imposing the condition of time-independence of the expectation value of the energy. The calculations are carried through without the use of the adiabatic approximation. For some closed-shell nuclei it is found that the lowest vibrational state should not be of the quadrupole type. The lifetimes of vibrational states are also calculated. The related problem of static deformations of a finite-well potential is discussed. Some numerical results for the quadrupole and octupole vibrations in $O^{16}$ and the quadrupole vibration in $Si^{28}$ are given.

539.14

## 4020 COLLECTIVE ROTATIONS OF NUCLEI. E.P.Gross.

Nuclear Phys., Vol. 14, No. 3, 389-97 (Jan. (1), 1960).

An analysis is made of descriptions of collective motions of nuclei which involve the application of projection operators to a localized nuclear wave-function $\psi$. This procedure leads to an incorrect description of centre-of-mass motion. The proposed remedy is to consider functions of the form $\psi e^{iS/\hbar}$, and to vary the functional form of the velocity potential S, subject to the constraint that the expectation value of the constant of motion has a given value for the state of collective motion. For translational motion this localized function already leads to the correct effective mass. The subsequent application of a projection operator mainly approves the zero-momentum wave-function. For rotational motion the velocity potential is expressed in terms of the excited states of a potential defined by $\psi$. The resulting moment of inertia is that of Inglis. The knowledge of the correct velocity potential for a given $\psi$ suggests approximate trial functions S which express the moments of inertia solely in terms of properties of the ground state $\psi$.

539.14

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### QUADRUPOLE ENHANCEMENT IN $O^{17}$ AND $F^{17}$.

G.Barton, D.M.Brink and L.M.Delves.

Nuclear Phys., Vol. 14, No. 2, 256-62 (Dec. [2], 1959).

A previous calculation of E2 enhancement is improved, first by refining the single-particle functions, and then by using Brillouin–Wigner in place of Rayleigh–Schroedinger perturbation theory. The higher-order correlations thus introduced enable one to bring the theory into agreement with the data on both $O^{17}$ and $F^{17}$. Finally, the extension of the theory to heavier nuclei is discussed.

539.14

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### ENHANCEMENT OF E2 TRANSITION PROBABILITY.

D.Kurath.

Nuclear Phys., Vol. 14, No. 3, 398-406 (Jan. (1), 1960).

The method of generator coordinates is applied to the calculation of E2 transition probabilities. Complete single-particle states in a deformed well are used as generator functions, and the transition from the first excited state to the ground state of $C^{12}$ is computed as an example. The degree of enhancement is found to be of a magnitude consistent with experiment. The effect of centre-of-mass motion and other factors affecting the validity of the result are discussed.

539.14 : 539.17

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### EXCITED STATES OF $B^{13}$.

G.C.Morrison and J.A.Galey.

Phys. Rev., Vol. 116, No. 6, 1583-4 (Dec. 15, 1959)

The energy levels in $B^{13}$ up to an excitation energy of 6 MeV was investigated by means of the reaction $Li^7(Li^7,p)B^{13}$ at an energy of 2 MeV for the incident $Li^7$ ions. Selection and identification of the out-going protons in the presence of deuterons, tritons, and alpha particles emitted in competing reactions was achieved with a proportional counter-CsI(Tl) scintillation counter telescope system which gives a measure of the dE/dx and E of the emitted particle. From the observed energy spectrum of protons emitted at 90°, the Q-value of the reaction leading to the ground state of $B^{13}$ was determined to be 5.97 ± 0.05 MeV in agreement with a previous measurement by Norbeck, and the energy of excitation of the first four levels in $B^{13}$ were determined to be 3.70 ± 0.05, 4.16 ± 0.05, 5.05 ± 0.08 and 5.5 ± 0.1 MeV. At 90° in the laboratory system the relative intensities of the proton groups leading to the ground state and first four excited states are in the ratios of 1.0:2.6:0.8:1.6:1.0, respectively.

539.14

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### EXCITED LEVELS IN $Mn^{56}$.

N.D'Angelo.

Phys. Rev., Vol. 117, No. 2, 510-13 (Jan. 15, 1960).

The half-lives of the first three excited levels of $Mn^{56}$ were measured by observing the cascade gamma rays from neutron capture in $Mn^{55}$. They are found to be $10.7^{+2}_{-3}$, 4.9 ± 0.6, and $\leq 0.5$ mμsec. A fairly plausible assignment of spins and parities to the first, second, and third excited levels of $Mn^{56}$ would seem to be $2^+$, $1^+$ and $2^+$, respectively. The technique described should be useful in those cases in which excited levels of unstable nuclei cannot be reached through beta decay.

539.14

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### HARMONIC OSCILLATOR WAVE FUNCTIONS IN NUCLEAR SPECTROSCOPY.

R.D.Lawson and M.Goeppert-Mayer.

Phys. Rev., Vol. 117, No. 1, 174-84 (Jan. 1, 1960).

Pairing energy calculations are generally carried out assuming the nucleon wave-functions are those of an harmonic oscillator. The two-body interaction is assumed to be some function of $\sigma_1$, $\sigma_2$ and $r_1-r_2$. Since the coordinates appear only in the form $r_1-r_2$, it is convenient to write the two-body wave-function in terms of the relative coordinate, $r=r_1-r_2$, and the centre-of-mass coordinate, $2R=r_1+r_2$. The eigenfunction in the new coordinates can be determined by noting that if the two particles are in the same oscillator level, then $\psi(r_1,r_2)$, which is an eigenfunction of $H_1+H_2$, is also an eigenfunction of $H_1$ alone. Transforming $H_1$ to relative and centre-of-mass coordinates implies that the operator $p\cdot P + mkr\cdot R$ (where m is the mass of the particle and k is the spring constant of the oscillator) must give zero when operating on the wave-function. This condition plus certain requirements arising from the radial form of the oscillator eigenfunctions is sufficient to determine the wave-function in the new coordinate system.

539.1

4026

### SPIN–ORBIT SPLITTINGS IN NUCLEI. II.

J.Sawicki.

Nuclear Phys., Vol. 13, No. 3, 350-9 (Nov. (1), 1959).

For Pt I see Abstr. 8493 (1959). The j-doublet splittings of single-particle nuclear levels are calculated in terms of the effective two-body spin–orbit interaction operator — the reaction matrix. The recent result of Brueckner et al. is used for the odd-state $K^-_{LS}$-operator corresponding to Gammel–Thaler potentials. On the same basis the even-state $K^+_{LS}$ is neglected. The exchange amplitudes of the $K^-_{LS}$-operator are taken into account and also the "higher derivative" terms. The self-consistent nuclear density of the $Ca^{40}$ nucleus and other forms of this density are used to calculate the doublet splittings of $Ca^{41}$. Satisfactory results are obtained. The doublet splittings of the nuclei $Pb^{209}$, $Bi^{209}$, $O^{17}$ and $He^5$ are discussed. A discussion is presented of the spin–orbit splittings in spheroidally deformed nuclei.

539.14

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### THE DETERMINATION OF THE MULTIPOLE ORDER OF NUCLEAR ELECTROMAGNETIC TRANSITIONS (BY MEASURING THE ANGULAR CORRELATION OF INTERNAL CONVERSION PAIRS).

P.Chevallier.

Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 11-12, 1389-438 (Nov.-Dec., 1959). In French.

The angular correlation of internal pairs gives the multipole order of the transition unambiguously and can consequently be used to deduce the spin and parity of excited states. Measurements have been made for the nuclei $Be^{10}$, $B^{10}$, $C^{14}$, $N^{14}$ which are of particular interest, since Inglis' intermediate coupling model has been developed for the P shell nuclei. Measurements have also been made on the magic number nucleus $Ca^{40}$. A $\beta$ spectrometer employing plastic phosphors with coincidence circuitry feeding into a pulse height analyser is described in detail. The results indicate the validity of the intermediate coupling model for the $B^{10}$ nucleus and to a more limited extent for the other nuclei. The method cannot distinguish between magnetic dipole and electric quadrupole transitions, but other further methods are suggested for doing this.

A.E.I. Research Laboratory

539.14

4028

### THE LEVEL DENSITY OF A SYSTEM OF INTERACTING NUCLEONS IN A SHELL.

R.Balian.

Nuclear Phys., Vol. 13, No. 4, 594-620 (Nov. [2], 1959). In French.

Using perturbation theory, the grand partition function is calculated for the completely degenerate system of interacting nucleons inside a shell. The level density is then derived by the Darwin–Fowler method. The purpose is to compare these results to exact levels known for a p-shell. The method gives fairly good results, even for a small number of particles, provided that the self-consistent field is taken into account, and the calculation is carried out in a coherent way; there is no advantage in performing the saddle point method after integration of the level density.

539.14

4029

### EVEN NUCLEI WITHOUT AN AXIS OF SYMMETRY.

N.Macdonald

Nuclear Phys. Vol. 14, No. 1, 70-7 (Dec. [1], 1959).

The low lying levels of even nuclei, and the electric quadrupole transition probabilities between certain of these levels, are discussed in terms of the rotation of a nucleus without axial symmetry. The moments of inertia of the nucleus are not restricted to those prescribed by the hydrodynamical model. A prescription due to Moszkowski (Abstr.8922 of 1956) is used. This contains a parameter p whose value depends on the residual interaction, and which in varying from 0 to 1 causes the moments of inertia to vary from the rigid body values to approximately the hydrodynamical values. To obtain agreement with the experimental data on the transitions it is necessary to have p larger than the values which give the correct values of the energy of the first excited state in the case of nuclei having a small deviation from axial symmetry.

539.14 : 539.11

4030 A SEARCH FOR PARITY MIXTURES IN NUCLEAR STATES. F.Boehm and U.Hauser.

clear Phys., Vol. 14, No. 4, 615-25 (Jan. (2), 1960).

The gamma-radiation emitted from nuclear states which ate
arized by beta-decay can show a 90° asymmetry if parity con-
rvation in nuclear states does not hold strictly. A beta–gamma
gular-correlation experiment yields linearly the quantity $\mathcal{R}$,
ere $\mathcal{R}$ is the relative amplitude of the irregular wave-function with
spect to the regular one and $\mathcal{F}$ is the matrix-element ratio of the
mma transitions. The measurements were performed with the
a–gamma decays of $A^{41} \rightarrow K^{41}$, $Xe^{133} \rightarrow Cs^{133}$, and $Lu^{177} \rightarrow Hf^{177}$ and
sulted in the following upper limits for : $6 \times 10^{-5}$ for $A^{41}$,
$10^{-4}$ to $8 \times 10^{-6}$ for $Xe^{133}$, and $3 \times 10^{-3}$ for $Lu^{177}$

539.14

4031 DISTRIBUTION OF PARTIAL RADIATIVE WIDTHS IN $Cu^{59}$ FOLLOWING PROTONS CAPTURE IN $Ni^{58}$.

H.Carver and G.A.Jones.

ys. Rev. Letters, Vol. 3, No. 12, 559-61 (Dec. 15, 1959).

Measurements of the radiative proton capture in $Ni^{58}$ have been
ade at 0° and at 90° to the proton beam. With these results it has
en possible to infer the spins of 23 of the excited levels in $Cu^{59}$,
d also to obtain information about the distribution of partial $\gamma$-ray
dths. The results compare well with a Porter–Thomas distribu-
n (Abstr. 1619 of 1957). J.A.Evans

539.14 : 539.12

STUDY OF $Be^8$ ENERGY LEVELS. See Abstr. 3976

539.14 : 539.17

4032 LEVELS OF $P^{29}$ FROM $Si^{28}(p,p)Si^{28}$ AND $Si^{28}(p,p')Si^{28*}$. J.Vorona, J.W.Olness, W.Haeberli and H.W.Lewis.

hys. Rev., Vol. 116, No. 6, 1563-71 (Dec. 15, 1959).

Differential cross-sections for the elastic and inelastic scat-
ering of protons from $Si^{28}$ were measured at centre-of-mass scat-
ering angles of 167.7°, 141.3°, 90.0°, and 54.7° for proton energies
etween 1.4 and 3.8 MeV. Resonances were observed at proton ener-
ies of 1.66, 2.09, and 2.88 MeV, in addition to the resonances at
.10, 3.34, 3.58, and 3.71 MeV which correspond to levels in $P^{29}$ re-
orted previously by other investigators from studies of the $\gamma$-rays
rom $Si^{28}(p,p'\gamma)Si^{28}$. Differential cross-sections and angular distri-
utions for inelastic scattering to the 1.78-MeV first excited state
f $Si^{28}$ were also measured for proton energies above 3 MeV.
easurements were made with a gas scattering chamber containing
ilane ($SiH_4$) as the target gas. The elastic scattering data were ana-
ysed in terms of the single-level approximation of the dispersion
heory to determine the resonance parameters. This analysis, to-
ether with the analysis of the inelastic scattering cross-sections
nd angular distributions, has resulted in the following assignments
f resonance energies (MeV) and spins and parities for the resonance
evels of $P^{29}$ : 1.660 $(3/2^-)$; 2.090 $(1/2^+)$; 2.88 $(1/2^-)$; 3.100 $(5/2^-)$;
.337 $(3/2^+)$; 3.575 $(3/2^-)$; and 3.711 $(3/2^+)$. The large reduced elas-
ic scattering widths of the p-wave resonances at 1.660 and 2.88 MeV
uggest that these levels correspond to single-particle excitations of
$P^{29}$.

539.14 : 539.17

4033 LOW-LYING ENERGY LEVELS IN $Sc^{41}$. H.S.Plendl and F.E.Steigert.

Phys. Rev., Vol. 116, No. 6, 1534-8 (Dec. 15, 1959).

The reaction $Ca^{40}(d,n)Sc^{41}$ was studied at 4.15 MeV bombarding
energy using nuclear emulsions as detectors. Four groups of
eutrons were observed with Q values of −0.57, −2.43, −2.64, and
.85 MeV. The observed angular distributions can be fitted with
distribution curves obtained from stripping analysis on the basis of
$r_0 = 6.0$ fermi and $l_p = 3, 1, 1, 1$, respectively. Two additional
groups of questionable assignment were observed at $Q = -1.13$ and
−1.41 MeV. Neutron groups from reactions on $C^{12}$ and $O^{16}$ were
also observed and served to confirm the beam calibration as well as
background and other correction methods.

539.14 : 539.17

4034 DETERMINATION OF THE EXCITED STATES OF OXYGEN USING THE $(\gamma, n)$ REACTION. D.Sadeh.

.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2313-14 (Nov. 30, 1959).
In French.

By means of a new and considerably improved method the dis-
continuities in the activation curve for the reaction $O^{16}(\gamma, n)O^{15}$ were re-measured. The discontinuities correspond to excited states of $O^{16}$. Four discontinuities, in addition to those already known, were found. J.D.Dowell

539.14

4035 THE FIRST EXCITED STATE OF $Tb^{159}$. A.Nemilov, A.N.Pisarevskii and L.D.Soshin.

Zh. eksper. teor. Fiz., Vol. 35, No. 3(9), 800-1 (Sept., 1958). In Russian. English translation in : Soviet Physics–JETP (New York), Vol. 35(8), No. 3, 554-5 (March, 1959).

A scintillation-spectrometer study of the $\gamma$-irradiation from $Dy^{159}$ was carried out. It is shown that the de-excitation of the first excited state (at 57.5 keV) of the product nucleus $Tb^{159}$ occurs with the emission of the Tb K-radiation, the conversion coefficient for the 57.5 keV line being ≥ 99%. L.L.Green

## RADIOACTIVITY . NUCLEAR DECAY

539.16 : 539.17

4036 PNEUMATIC TUBES SPEED ACTIVATION ANALYSIS. W.W.Meinke.

Nucleonics, Vol. 17, No. 9, 86-9 (Sept., 1959).

A full description of a pneumatic transfer system used for short irradiations of samples in a 1 MW pool reactor. Samples are irradiated for periods of 3 to 20 sec and can be ready for counting approx. 5 sec after irradiation. Threshold activation measurements of the irradiation spectrum have been made. Examples of radiochemical analyses using short-lived isotopes are included. R.D.Smith

539.16

4037 LARGE PROPORTIONAL COUNTER SPECTROMETER FOR THE STUDY OF RADIOACTIVE SAMPLES WITH LOW SPECIFIC ACTIVITY.

J.T.Holloway, D.C.Lu and D.J.Zaffarano.

Rev. sci. Instrum., Vol. 31, No. 2, 91-5 (Feb., 1960).

The design and construction of a cylindrical proportional counter 36 in. long, 12 in. in diameter is described, and its performance as a spectrometer for studying soft radiations from radiative samples of low specific activity is given. The counter tank is operated in an axial magnetic field of 2500 gauss to constrain beta-rays to helical paths. A line width of 3.4% ($\Delta E/E$) is obtained for 6.25 keV electrons from a $Cs^{137}$ source mounted on a thin film placed within the tank. Simple theory would predict 2.2%. Beta spectra are readily obtained with sources having total activities less than 10 mμC.

539.16

4038 AN INSTRUMENT WITH A LOGARITHMIC SCALE FOR MEASURING INTENSITY OF GAMMA RADIATION.

R.Génin.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 36A-38A (March, 1957). In French.

This instrument uses the rapid variation of the gain of a photomultiplier with dynode voltage, which is controlled by the photomultiplier current. The scale is logarithmically proportional to the intensity of the gamma-radiation and covers a wide range of intensities without scale switching.

539.16

4039 THE EFFICIENCY OF A $\gamma$-RAY SUMMATION SPECTROMETER. J.Kopecký and J.Kajfosz.

Czech. J. Phys., Vol. 9, No. 2, 268-9 (1959).

The efficiency of a two-crystal scintillation spectrometer working on the principle of pulse summation (Abstr. 11334 of 1959) was calculated as a function of $\gamma$-radiation energy, taking into account the self-absorption of scattered radiation in the first crystal and the dependence of the scattering angle on the energy. The result shows that the efficiency decreases with increasing energy up to 3.5 MeV and increases for higher energies. I.C.Demetsopoullos

539.16

4040 A DEVICE FOR AUTOMATIZATION OF A SINGLE CHANNEL SCINTILLATION GAMMA SPECTROMETER.

A.N.Pisarevskii and L.D.Soshin.
Pribory i Tekh. Eksper., 1959, No. 3, 90-3 (May-June). In Russian.

The device fairly briefly described consists of a differential discriminator, scaling circuit, storage circuit, recording equipment, automatic bias voltage divider, control circuit and timer. No complicated step switches etc. are used. The number of possible points on the spectrum is 127, using all 14 of the resistors in the automatic divider. The accuracy obtained depends basically on the type of recording equipment used. A fairly detailed circuit diagram is included, and the gamma spectrum of Cs$^{137}$ is used as an example.

D.E.Brown

539.16 : 539.23

### NEW METHOD FOR THE PREPARATION OF THIN FILMS OF RADIOACTIVE MATERIAL. See Abstr. 3281

539.16 : 523.5

4041

### DETERMINATION OF THE AGE OF THE ELEMENTS.

J.H.Reynolds.
Phys. Rev. Letters, Vol. 4, No. 1, 8-10 (Jan. 1, 1960).

Measurements are described of the isotopic composition of xenon contained in the stone meteorite Richardton. Significant deviations in the mass spectrum compared with terrestial xenon were found, particularly at mass number 129. On the assumption that most of the excess Xe$^{129}$ was formed by the decay process I$^{129}\xrightarrow{1.7 \times 10^7 \text{yr}}$Xe$^{129}$ the time elapsing between the formation of the elements and the meteorite is calculated as $(0.35 \pm 0.06) \times 10^9$ yr. Taking the accepted age of the chondrites as $4.6 \times 10^9$ yr, the age of the elements is then $4.95 \times 10^9$ yr. Modes of production of the Xe$^{129}$ other than by decay of I$^{129}$ are discussed and shown to lead to much smaller quantities than those observed.

R.H.Thomas

539.16

4042

### ON THE "HOT" PARTICLES IN ATMOSPHERIC AEROSOLS.

J.A.Schedling and W.A.Müller.
S. B. Österr. Akad. Wiss. math. - nat. Kl. Abt. II, Vol. 158, No. 1-4 115-22 (1959). In German.

These are strongly radioactive particles of diameter 1-2 $\mu$ and contain Ce$^{141}$, Ce$^{144}$, Ru$^{103}$, Zr$^{95}$ and Nb$^{95}$.

J.M.Hough

539.16

4043

### ABSOLUTE CALIBRATION OF A COUNTER ARRANGEMENT FOR Sr$^{89}$,Y$^{90}$, and Ba—La$^{140}$, by Sr—Y$^{90}$ STANDARDS.

G.Herrmann and K.Habel.
Nukleonik, Vol. 1, No. 7, 241-5 (Aug., 1959). In German.

In order to compare the absolute activities of Sr$^{89}$, Y$^{90}$ and Ba$^{140}$ in atmospheric precipitation, a 2$\pi$-counter tube and an end-window G.M. tube were calibrated to give absolute counting rates for Sr$^{89}$, Y$^{90}$, Ba—La$^{140}$ and Sr—Y$^{90}$. The influence of layer thickness of the preparation was also investigated. The results showed that the absolute counting rates for the compounds of short half-life could be obtained by using a previously calibrated Sr—Y$^{90}$ source of long half-life as a standard.

J.Dutton

539.16

4044

### $\alpha$-RADIOACTIVITY OF CERIUM-142.

F.E.Senftle, T.W.Stern and V.P.Alenka.
Nature (London), Vol. 184, 630 (Aug. 22, 1959).

A search was made for the $\alpha$-decay of Ce$^{142}$ by loading C2 nuclear emulsion with an isotopically enriched sample of Ce$^{142}$ (90.2%). The emulsion was exposed for 125 days and then scanned for $\alpha$-particle tracks, none being found. A control experiment using unenriched cerium gave a small number of tracks from samarium impurities. This failure to observe tracks is in conflict with the previous experiment of Riezler and Kauw (Abstr. 3855 of 1959) who found a half-life of $5.1 \times 10^{15}$ yr; however, failure to observe $\alpha$-tracks in the present experiment leads to a minimum estimate of the half-life as $10^{16}$ yr which does not disagree within the uncertainty quoted of the experiment of Riezler and Kauw.

R.H.Thomas

539.16

4045

### THE TRANSMUTATION Am$^{241}\xrightarrow[\gamma]{\alpha}$Np$^{237}$.

S.Rosenblum, M.Valadares and J.Milsted.
J. Phys. Radium, Vol. 18, No. 11, 609-18 (Nov., 1957). In French.

Several papers on $\alpha$ fine-structure and conversion electrons have been published since 1948. In this paper an up-to-date survey is given of all known contributions including the authors latest results.

539.16 : 539.17

### ALPHA DECAY AND FISSION OF ALIGNED NUCLEI. See Abstr. 2690.

539.16

4046

### THE ANGULAR DISTRIBUTION OF $\beta$ PARTICLES.

G.Rakavy.
Nuclear Phys., Vol. 14, No. 4, 661-81 (Jan. (2), 1960).

A general formula is given for the angular distribution and polarization of electrons emitted in $\beta$-decay from oriented nuclei. The formula is convenient for actual calculations on the one hand, and transparent enough to see in a straightforward way the influence of the various interaction types on the other hand. The result is also in a form convenient for switching it into the general formalism of angular correlations so as to get $\beta$—$\gamma$ correlations (with or without polarization observation).

539.16

4047

### ON THE CONSERVED POLAR VECTOR CURRENT IN BETA-DECAY.

R.J.Blin-Stoyle, V.Gupta and J.S.Thomson.
Nuclear Phys., Vol. 14, No. 4, 685-92 (Jan. (2), 1960).

It is suggested that if the polar vector current in beta-decay is not conserved, mesonic exchange effects may be appreciable in $0^+ \rightarrow 0^+$ transitions. Experimental data at present indicate that such effects are not present to more than 5% in O$^{14}$ → N$^{14}$.

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4048

### "NUCLEON-STRUCTURAL" CORRECTIONS TO FIRST FORBIDDEN UNIQUE BETA TRANSITIONS.

J.F.Dreitlein.
Phys. Rev., Vol. 116, No. 6, 1604-9 (Dec. 15, 1959).

The coupling of leptons to a conserved isovector current is shown to result in a small change in the shape of the electron momentum spectrum in forbidden unique beta transitions. The experimental advantages and disadvantages of studying such nucleon-structural effect in forbidden unique transitions rather than in allowed transitions, as suggested by Gell-Mann, are discussed. To facilitate the computations, the beta-decay interaction Hamiltonian is written in a form in which the terms leading to the "nucleon-structural" corrections associated with the coupling of the leptons to a conserved isovector current and the terms leading to effects of comparable order of magnitude are simply identified.

539.16

4049

### SEARCH FOR PSEUDOSCALAR INTERACTION IN $\frac{1}{2}+ \rightarrow \frac{1}{2}-$ $\beta$-DECAY TRANSITION.

S.Cuperman.
Phys. Rev., Vol. 117, No. 1, 185-6 (Jan. 1, 1960).

The longitudinal polarization of the electrons emitted by Tl$^{207}$ ($\frac{1}{2}+ \rightarrow \frac{1}{2}-$) was measured by double Coulomb scattering. Within the experimental error, a $-v/c$ polarization was obtained. In order to deduce the amount of pseudoscalar contributions, one must know the other nuclear matrix elements. They were taken from a theoretical shell-model calculation and a j—j coupling single-particle model. Assuming $C_S = C_T = 0$, two-component neutrino theory [which predicts opposite polarization in the case of (V,A) and P interactions], left-handed neutrino, and time-reversal invariance, as well as a surface distribution of the nuclear charge, one finds $|x|^2 \leq 4.4 \times 10^{-2}$ (if $C_P/C_A > 0$), with

$$x = -i(C_P/C_A)[\int \beta\gamma_5 / \int \sigma \cdot r]\rho,$$

where $\rho$ is the nuclear radius.

539.16 : 539.11

4050

### THE ENERGY DEPENDENCE OF THE POLARIZATION OF ELECTRONS AND TIME PARITY.

A.I.Alikhanov, G.P.Eliseyev and V.A.Luibimov.
Nuclear Phys., Vol. 13, No. 4, 541-8 (Nov. (2), 1959).

New measurements of the energy dependence of the polarization of the $\beta$-electrons from RaE show no significant violation of time parity.

539.16

4051

### KRYPTON IN A CAGE—CLATHRATE BETA SOURCES.

D.J.Chleck and C.A.Ziegler.
Nucleonics, Vol. 17, No. 9, 130-3 (Sept., 1959).

Safe $\beta$ sources can be made by trapping Kr$^{85}$ in a 3-dimensional organic crystalline cage ("clathrate"). Preparation is by slow cooling of quinol from just above its melting point in the presence of krypton at 60 atmospheres. The density of krypton trapped in the clathrate is equal to gas at 25.8 atm and 15°C, and a source strength of 3 curies per gram has been achieved. The source is very stable, though the krypton can be released controllably by dissolving the quinol. Possible applications are discussed.

R.D.Smith

539.16 : 539.18

4052

### CHARGE SPECTROMETRY FOR $Kr^{79}$-$Br^{79}$.

A.H.Snell, F.Pleasonton and J.L.Need.

Phys. Rev., Vol. 116, No. 6, 1548-51 (Dec. 15, 1959).

The distribution in charge of the $Br^{79}$ atoms formed in the complex electron capture and $\beta^+$ decay of radioactive $Kr^{79}$ has been found to consist of two components; one to be mostly associated with the $\beta^+$ transitions, and the other with the electron capture transitions. Because of a difference in instrumental efficiency, the relative intensity of the two components is undetermined in the present work, but if the value of 9.3 is assumed for the total electron-capture/$\beta^+$ ratio, then the spectrum for the successive charges −1, 0, 1...+13 is as follows (figures in percent): 7.7, 3.7 (estimated), 4.0, .7, 12.7, 16.0, 14.3, 13.6, 11.3, 7.7, 3.3, 0.68, 0.13, 0.054, and 0.014, respectively.

539.16

4053

### DETERMINATION OF THE LOW-ENERGY REGION OF THE TRITIUM BETA SPECTRUM.

D.C.Conway and W.H.Johnston.

Phys. Rev., Vol. 116, No. 6, 1544-7 (Dec. 15, 1959).

The tritium beta spectrum was determined in a proportional counter spectrometer fitted with field-adjusting electrodes down to an energy of 200 eV. Below 1.2 keV the experimental spectra exhibit positive deviation from the theoretical spectrum which was corrected for the screening effect and for counter resolution. Various possible explanations for the deviation, which amounts to +6.5% at 0.3 keV, are examined. A possible explanation is that w, the energy to produce an ion pair in the counting gas, increases by several percent in the energy interval 1.2 to 0.25 keV.

539.16

4054

### DECAY OF $^{140}Ba$.

P.Boskma and H.de Waard.

Nuclear Phys., Vol. 14, No. 1, 145-54 (Dec. [1], 1959).

The decay of $Ba^{140}$ to $La^{140}$ was investigated by means of a coincidence magnetic spectrometer and β- and γ-scintillation coincidence techniques. A uniquely determined level scheme (of $Ba^{140}$) can be given and the $La^{140}$ levels are discussed.

539.16

4055

### INVESTIGATIONS ON THE DECAY OF $^{103}Ag$, $^{104}Ag$ AND $^{104}Rh$.

R.K.Girgis and R.Van Lieshout.

Nuclear Phys., Vol. 13, No. 4, 493-508 (Nov. [2], 1959).

The $Ag^{103}$ and $Ag^{104}$ nuclides were produced by irradiating $Rh^{103}$ with alpha-particles. Bombarding energies of 50, 40, 30 and 20 MeV were used, whereby these nuclides were produced in different proportions, thus facilitating the assignment of the various radiation characteristics. The 60 minute $Ag^{103}$ was found to decay mainly by an ~ 1.2 MeV positron transition to the ground state of $^{103}Pd$; a weak gamma-ray of 120 keV may also be present in the decay of this nuclide. Gamma-rays of 555, 745, 780, 860, 935, 1260, 1340, 1540, 1640 and 1810 keV were assigned with certainty to the decay of the 70 minutes $Ag^{104}$. Most of these gamma-rays also occur in the decay of 4.4 minute $Rh^{104}$, which was examined under the same experimental conditions. No positrons with energy > 1.2 MeV are present in the 70 minute $Ag^{104}$ activity. The decay of the 27 minute $Ag^{104}$ shows gamma-rays of 555 and 780 keV and two positron groups of 2.6 and 1.9 MeV. A level scheme for $Pd^{104}$ is deduced from the decay scheme of $Ag^{104}$.

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### THE LEVEL SCHEME OF $^{104}Pd$ (ADDENDUM).

R.K.Girgis and R.Van Lieshout.

Nuclear Phys., Vol. 13, No. 4, 509-10 (Nov. [2], 1959).

The results obtained in the study of the decay of $Rh^{104}$ and $Ag^{104}$ (see preceding abstract) are reviewed in the light of the new spin value reported for 70 minute $Ag^{104}$.

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### THE DISINTEGRATION OF $La^{131}$.

C.B.Creager, C.W.Kocher and A.C.G.Mitchell.

Nuclear Phys., Vol. 14, No. 4, 578-88 (Jan. (2), 1960).

The decay of $La^{131}$ was studied with the help of a magnetic lens spectrometer, scintillation spectrometers and scintillation coincidence spectrometers. The half-life is 61 ± 2 min. Three positron groups were found having end-point energies and relative abundances as follows: 1.939 ± 0.045 MeV (27%), 1.424 ± 0.036 MeV (56%), 0.704 ± 0.045 MeV (17%). Gamma-rays were found at 115, 169, 214, 254, 285, 364, 417, 445, 511 (annihilation radiation), 597 and 878 keV. The line at 115 keV is strongly internally converted. A disintegration scheme ($La^{131} \rightarrow Ba^{131}$) and $Ba^{131}$ levels are given.

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### NEW NEUTRON-DEFICIENT ISOTOPE OF CERIUM.

W.R.Ware and E.O.Wiig.

Phys. Rev., Vol. 117, No. 1, 191-3 (Jan. 1, 1960).

$Ce^{132}$, a positron emitter with a half-life of 4.2 ± 0.2 hr, was identified through its generic relationship to the known daughter nuclide, $La^{132}$. An activity of 30 min half-life and 4.2 MeV maximum positron energy, which may be due to $Ce^{131}$, was also observed.

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### RADIOACTIVE DECAY OF LUTETIUM-174.

R.G.Wilson and M.L.Pool.

Phys. Rev., Vol. 117, No. 2, 517-19 (Jan. 15, 1960).

Ytterbium oxide enriched to 98.4% in the 174 mass number was irradiated with 6 MeV protons. An activity of approximately 165 day half-life was produced and assigned to $Lu^{174}$ by the identification of the ytterbium K X-ray and of the activities produced by similar proton irradiations of the other enriched isotopes of ytterbium. The observed activity of $Lu^{174}$ consists of the L and K X-rays of ytterbium and 76.6 and 1228 keV gamma rays which are in coincidence. Because no β-radiation exists in the activity of $Lu^{174}$, the mode of decay is solely by electron capture to $Yb^{174}$. Approximately 31% of the disintegrations of $Lu^{174}$ are to the ground state of $Yb^{174}$. In addition to the 76.6 keV level of $Yb^{174}$, there is a 1305 keV level with a spin of 0+. The transitions of $Lu^{174}$ to the 1305 keV level of $Yb^{174}$ are by L-capture only and the percentages of electron capture to the 76.6 and 1305 keV levels of $Yb^{174}$ are approximately 59 and 10 respectively. A spin of 1- is assigned to the ground state of $Lu^{174}$.

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### DECAY OF $Gd^{146}$ AND $Eu^{146}$.

N.M.Antonieva, A.A.Bashilov, B.S.Dzhelepov and V.A Sergienko.

Nuclear Phys., Vol. 14, No. 3, 438-42 (Jan. (1), 1960).

The spectra of conversion electrons of neutrino-deficient isotopes $Gd^{146}$ and $Eu^{146}$ were investigated. In the case of $Gd^{146}$ three nuclear transitions with energies of 114.8, 115.5 and 155 keV were observed and the coincidences among their conversion electrons were studied. In the case of $Eu^{146}$ transitions with energies of 630 and 742 keV were observed. $Gd^{146} \rightarrow Eu^{146} \rightarrow Sm^{146}$ decay scheme and $Sm^{146}$ levels are given.

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### TRANSVERSE POLARIZATION OF K-CONVERSION ELECTRONS FOLLOWING THE BETA DECAY OF $Hg^{203}$.

J.E.Alberghini and R.M.Steffen.

Nuclear Phys., Vol. 14, No. 2, 199-204 (Dec. [2], 1959).

The degree of transverse polarization of the K-conversion electrons following the first-forbidden beta-decay of $Hg^{203}$ was measured. The electron polarization was observed by means of the left—right asymmetry in a Mott-scattering process. The degree of polarization of the conversion electrons was determined as $P_{\perp}(\theta) = (0.35 \pm 0.07)\,(v/c)\sin\theta$, where θ is the angle between the beta-particle direction and the conversion-electron direction. The analysis of the result within the framework of the ξ-approximation for non-unique first-forbidden beta-decay gives strong support to the decay scheme $(\frac{3}{2})\ \beta\ (\frac{3}{2})$ c.e. $(\frac{1}{2})$.

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### ON THE DECAY OF $Se^{75}$.

E.P.Grigoriev and A.V.Zolotavin.

Nuclear Phys., Vol. 14, No. 3, 442-58 (Jan. (1), 1960).

The conversion and γ-ray spectrum of $Se^{75}$ was investigated with a $\pi\sqrt{2}$ double-focusing spectrometer possessing a line half-width of 0.4%. The relative conversion and γ-line intensities, conversion coefficients and transition multipolarities are determined.

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### VIBRATIONAL STATES IN $U^{234}$ EXCITED BY $Np^{234}$ DECAY AND EVIDENCE FOR AN E0-TRANSITION BETWEEN STATES WITH $1 \neq 0$.

C.J.Gallagher Jr and T.D.Thomas.

Nuclear Phys., Vol. 14, No. 1, 1-20 (Dec. [1], 1959).

Transitions following the EC-capture decay of 4.4 day $Np^{234}$ were investigated with 99, 160 and 350 gauss permanent magnets, a solenoidal "long-lens" spectrometer, and NaI:Tl scintillation detectors with a 100 channel analyser. Many internal-conversion electron lines were observed, and assigned to transitions at 43.49, 99.70, 233.6, 234.6, 238.6, 247.9, 297.6, 450.5, 482.8, 485.1, 515.7, 525.9, 556.8, 744.1, 751.7, 767.9, 787.8, 793.8, 810.0, 812, 854, 1003, 1105, 1196, 1240, 1395, 1439, 1531, 1562, 1575 and

1606 keV. A few other weak electron lines were observed, but not assigned to transitions. Conversion electron transitions following $Np^{236}$, $Np^{238}$ and $Np^{239}$ decay were also observed on the same plates and identified, helping to insure correctness of the isotopic assignment of the $U^{234}$ transitions. The above transitions were interpreted to establish levels in $U^{234}$ at 43.49, 143.2, 788, 812, 854, 1049, 1090, 1092, 1240, 1340, 1439, 1575 and 1606 keV. The 812 keV E0 transition was resolved into two components, one of which is interpreted to be an E0 transition between two 2+ states. Transition multipolarities and possible level spin and parity assignments are discussed. A comparison of the known data on relative energies of vibrational states indicates that the $\beta$-vibrational states have lower energies than the $\gamma$-vibrational states in the few nuclei where the energies of both are known.

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### 4064 INVESTIGATION OF $\gamma$-RAYS FROM THE DECAY OF $As^{78}$. Yu.A.Nemilov, A.N.Pisarevskii and L.D.Soshin.

Zh. eksper. teor. Fiz., Vol. 35, No. 3(9), 801-2 (Sept., 1958). In Russian. English translation in: Soviet Physics—JETP (New York), Vol. 35(8), No. 3, 555-6 (March, 1959).

Measurements were carried out by means of a scintillation $\gamma$-spectrometer with a 128-channel analyser, the various $\gamma$-lines being obtained using: (1) a conventional single-crystal spectrometer and (2) a $4\pi$ integrating spectrometer. The 500 keV line (T = 5-6 min), obtained using (1), is supposed to result from de-excitation of a metastable state formed when neutrons react with $Se^{78}$ (from which $As^{78}$ was obtained). A possible decay scheme of $As^{78}$ is suggested. F.Lachman

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### 4065 ON THE DECAY OF $^{76}$As. R.K.Girgis, R.A.Ricci and R.Van Lieshout.

Nuclear Phys., Vol. 13, No. 4, 461-72 (Nov. [2], 1959).

The gamma-rays emitted in the decay of $As^{76}$ were investigated with the help of scintillation spectrometers. Gamma—gamma coincidences were found using the summing technique with a cylindrical well-type crystal and also with a fast—slow coincidence set-up. New gamma-rays of 760, 860, 1530, 1630, 1860 and 2110 keV were found. The existence of the recently reported gamma-rays of 2410 and 2640 keV and that of the disputed 1770 keV gamma ray is confirmed. It is shown that both the 560 and 1210 keV gamma peaks correspond to more than one gamma-transition. Results of the detailed analysis of the spectrum are given. A decay scheme of $As^{76}$ to $Se^{76}$ levels is proposed.

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### 4066 THE DECAY OF $^{76}$Br. R.K.Girgis, R.A.Ricci, R.Van Lieshout and J.Konijn.

Nuclear Phys., Vol. 13, No. 4, 473-84 (Nov. [2], 1959).

The radiations of 16.1 ± 0.2 hour $Br^{76}$ were studied with single-crystal and coincidence-scintillation spectrometers; beta—gamma coincidences were also studied with a proportional counter-scintillation crystal coincidence spectrometer. Three positron groups of maximum energies (and relative intensities) of 3.68 ± 0.10 (45+), 3.15 ± 0.10 (100+) and 1.9 ± 0.2 MeV (<40+) were resolved; the ratio of electron capture to positron emission was determined as 0.6 ± 0.2. The 3.68 MeV positron group is a ground-state transition, since it is not in coincidence with the 0.56 MeV gamma-ray. A total number of 15 gamma-rays with energies ranging from 0.56 to 4.42 MeV were resolved. For a few selected gamma-rays coincidence measurements performed with the proportional counter yielded the relative amount of positrons feeding these gamma transitions. In view of the complexity of the gamma-ray spectrum no unambiguous decay scheme for $Br^{76}$ can be proposed. Some features of the level scheme of $Se^{76}$ are discussed eapecially in relation to the results obtained from a separate study of the decay of $As^{76}$. (See preceding abstract).

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### 4067 THE ANGULAR DISTRIBUTION OF $Au^{198}$ RADIATION SCATTERED IN THE AIR ABOVE THE GROUND.

V.N.Sakharov, V.I.Kolesnikov-Svinarev, V.A.Nazarenko and E.I.Zabidarov.

Atomnaya Energiya, Vol. 7, No. 3, 266-7 (Sept., 1959). In Russian.

A 10 kc $Au^{198}$ source was used, and the total intensity of radiation was measured with a Geiger counter at distances up to 600 m with the source either 1.5 or 25 m above the ground. The angular distribution was measured with a four-counter detector placed at various distances behind a thick lead screen, and was found to be independent of distance at distances over ~ 150 m. J.B.Sykes

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### 4068 GAMMA RADIATION FROM $^{77}$Br. R.K.Girgis, R.A.Ricci and R.van Lieshout.

Nuclear Phys., Vol. 13, No. 4, 485-92 (Nov. (2), 1959).

The gamma-ray spectrum emitted in the decay of $Br^{77}$ was studied with a scintillation spectrometer. Energy values and relative intensities of the various gamma-rays were determined. In addition to gamma-transitions known from other studies on the decay of $Br^{77}$, three new weak gamma-rays were found. These have energies of 200 ± 10, 380 ± 10 and 450 ± 10 keV and involve a level at 455 keV in $Se^{77}$ known from Coulomb excitation experiments. A decay scheme is proposed and log ft-values for the various capture branches are calculated.

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### 4069 DIRECTIONAL AND POLARIZATION CORRELATION MEASUREMENTS ON $Eu^{152m}$. G.T.Wood.

Phys. Rev., Vol. 116, No. 6, 1499-504 (Dec. 15, 1959).

The spins and parities of the 1511 keV level in $Sm^{152}$ and the 1315 keV level in $Gd^{152}$ are discussed on the basis of directional correlation and polarization-direction correlation measurements on the 1389-122 keV and 970-344 keV gamma—gamma cascades, following the decay of 9 hr $Eu^{152m}$. Both levels have been assigned spin and parity $1^-$. In order to check the apparatus on cascades known on the basis of previous measurements, directional and polarization-direction correlation measurements were also made on the 842-122 keV (from 9 hr $Eu^{152m}$) and 1409-122 keV (from 12 yr $Eu^{152}$) cascades in $Sm^{152}$.

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### 4070 INVESTIGATIONS OF THE DECAY-SCHEME OF $Fe^{59}$. D.Berényi, G.Máthé and T.Scharbert.

Nuclear Phys., Vol. 14, No. 3, 459-64 (Jan. (1), 1960).

The authors examined the gamma-ray spectrum and gamma—gamma coincidence spectrum of $Fe^{59}$ by means of scintillation spectr meters. The two lines of high energy were found to be 1.08 and 1.27 MeV respectively. Between these lines no genuine coincidence could be detected. Analysis of beta-spectrum and beta—gamma coincidence spectra yielded the beta groups of 275 ± 5 and 455 ± 5 keV end-point energies. The intensity of these was 44.6 and 55.4% respectively, and their corresponding log ft values were 5.3 and 6.1 The relative intensity of the high-energy beta-transition directly int the ground state was found to be less than 0.5%.

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### 4071 LEVELS IN $^{200}$Hg POPULATED FROM THE DECAY OF $^{200}$Au. R.K.Girgis, R.A.Ricci and R. Van Lieshout.

Nuclear Phys., Vol. 14, No. 4, 589-96 (Jan. 2, 1960).

The decay of 48 minute $Au^{200}$ was investigated (a scheme is given). Only three gamma-rays (370, 1225 and 1600 keV) were found to follow the decay of this isotope. Excited states at 370 and 1595 keV in $Hg^{200}$ can accommodate these gamma-rays. No gamma-rays were found to correspond to the excitation or the de-excitation of a level at 950 keV, which was observed in both the neutron capture gamma-ray work on $Hg^{199}$ and in the beta-decay investigations of $Tl^{200}$. Evidence is presented for a new gold activity ($Au^{>199}$) with a half-life of 19 ± 2 hours. See also the following abstract.

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### 4072 LEVELS IN $^{200}$Hg STUDIED FROM THE DECAY OF $^{200}$Tl. R.K.Gupta, R.K.Girgis and R.Van Lieshout.

Nuclear Phys., Vol. 14, No. 4, 597-605 (Jan.(2), 1960).

The gamma-ray spectrum from the decay of $Tl^{200}$ was investigated with a scintillation spectrometer. The ground-state transitions from the 1595, 1732 and 1885 keV levels in $Hg^{200}$ were detected. From summing studies and from the direct gamma-ray spectrum, the existence of new levels at 2000 ± 20, 2280 ± 20 and 2400 ± 30 keV in $Hg^{200}$, populated from the decay of $Tl^{200}$, is inferred. The decay scheme is given for $Tl^{200}$.

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### 4073 ON THE DECAY OF $^{123}$I. R.K.Gupta.

Nuclear Phys., Vol. 14, No. 4, 606-14 (Jan. (2), 1960).

The gamma rays from the decay of $I^{123}$, produced by alpha-bombardment of enriched $Sb^{121}$ were investigated with a scintillation spectrometer. New gamma-rays of 275 ± 10, 320 ± 10, 340 ± 10, 380 ± 10, 435 ± 10, 500 ± 10 keV emitted in the decay of $I^{123}$ were detected. From summing studies and from the direct gamma-ray spectrum of the existence of levels at 435 and 502 keV in $Te^{123}$, known from Coulomb excitation, was confirmed. In addition, the existemce new levels at 690 ± 10 and 320 ± 10 keV in $Te^{123}$ is inferred. A cay scheme is given for $I^{123}$. New gamma rays of 275 ± 10 and 0 ± 10 keV belonging to the decay of $I^{121}$ were also detected.

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### GAMMA RAY SPECTRA AND PARAMETERS OF NEUTRON RESONANCES IN MERCURY.

R.Bird, M.C.Moxon and F.W.K.Firk.

uclear Phys., Vol. 13, No. 4, 525-40 (Nov. (2), 1959).

The gamma-ray spectra from resonant neutron capture in ercury suggest that resonances in $Hg^{199}$ at 33.5, 175, 263 and 315 eV ave J = 1, while the 128 eV resonance has J = 0. These results are n agreement with the results of transmission measurements. Resnance parameters are determined for seven resonances up to 09 eV. The gamma-ray spectra for resonances in other isotopes $Hg^{198}$, $Hg^{201}$) show end-points which are in agreement with binding nergies calculated from mass measurements. The shape of the arious spectra show the presence of fluctuations of at least 5 : 1 n the intensity of individual gamma-rays, from resonance to resonnce. The presence of gamma-ray peaks at either 368 or 439 keV ssists in the allocation of resonances to either $Hg^{199}$ or $Hg^{201}$.

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### LIFETIME OF THE 3.56 MeV STATE OF $Li^6$.

L.Cohen and R.A.Tobin.

Nuclear Phys., Vol. 14, No. 2, 243-7 (Dec. [2], 1959).

The bremsstrahlung beam from a 25 MeV betatron was used o excite the 3.56 MeV state in $Li^6$. The gamma-radiation resulting rom the de-excitation of these nuclei was observed with and without a $Li^6$ absorber inserted in the primary beam. Assuming a spin ssignment J = 0 for the excited state, and using a calculated Doppler width of 11.3 eV for enriched lithium metal, an analysis of he data yields a mean lifetime of $(7.2^{+1.5}_{-1.3}) \times 10^{-17}$ sec.

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### NUCLEAR ORIENTATION OF $Mn^{56}$.

R.W.Bauer and M.Deutsch.

Phys. Rev., Vol. 117, No. 2, 519-25 (Jan. 15, 1960).

The angular distribution and circular polarization of the gamma-rays emitted from 2.6 hr $Mn^{56}$, polarized at low temperatures in cerium magnesium nitrate, were measured. Comparing the angular distribtion results with angular correlation data it is possible to establish the spins of the 2.65 and 2.98 MeV excited states of $Fe^{56}$ as 2 uniquely. The amplitude mixing ratios δ(E2/M1) for the 1.81 and 2.13 MeV γ-rays are shown to be +0.11 ± 0.06 and −0.27 ± 0.03, respectively. Gamma anisotropies from aligned $Mn^{56}$ in the same cooling salt were studied; the results are compared with other Mn alignment experiments. From a simultaneous measurement of the angular distribution of the γ-rays from polarized $Mn^{52}$ and $Mn^{56}$, the ratio of the nuclear g-values $(g_{52}/g_{56}) = 0.47 \pm 0.05$ was determined, giving $\mu_{56} = 3.35 \pm 0.35$ n.m. The results of the circular polarization experiment determine $\mu_{56}$ to be positive.

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### GAMMA RAY CASCADES IN $O^{15}$.

D.F.Hebbard and B.Povh.

Nuclear Phys., Vol. 13, No. 5, 642-54 (Nov. [3], 1959).

The gamma-rays from the reaction $N^{14}(p,\gamma)O^{15}$ were investigated over the proton energy range from 950 to 1560 keV. It was found that the 8.29 MeV level (1060 keV resonance) in $O^{15}$ cascades weakly through a level at 7.17 MeV and through the known level at 6.15 MeV, in addition to the transitions already known to the 5.2 MeV levels and the ground state. The radiative widths of the 8.29 MeV level for transitions to the ground state 5.2 MeV levels, 6.15 MeV level, and 7.17 MeV level are respectively 0.54 eV, 0.33 eV, 0.06 eV and 0.02 eV. The non-resonant production of $O^{15}$ in the above proton energy range is almost entirely accounted for by a transition through the 6.79 MeV level in $O^{15}$. At the 8.75 MeV level (1550 keV resonance) the transitions to the ground state, 5.2 MeV states, 6.8 MeV states, and 7.17 MeV state all appear to be weakly resonant.

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### SEARCH FOR LOW-ENERGY GAMMA RAYS IN $O^{16}$.

W.W.Pratt and R.G.Cochran.

Phys. Rev., Vol. 116, No. 6, 1578-80 (Dec. 15, 1959).

In the expectation that at least one low-energy transition from the fourth excited state of $O^{16}$ may compete to an observable extent with the 7.11 MeV ground-state transition, a search was made for the 0.97 MeV ($1^- \rightarrow 3^-$) and the 1.05 MeV ($1^- \rightarrow 0^+$) gamma rays. Limiting values, I(7.11)/I(0.97) >~ 200 and I(7.11)/I(1.05) >~ 370, were found for the branching ratios.

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### THE USE OF DIGITAL RECORDING ON MAGNETIC TAPE FOR THE STUDY OF γ-RAYS FROM RESONANT NEUTRON CAPTURE IN PLATINUM.

J.R.Bird and J.R.Waters.

Nuclear Phys., Vol. 14, No. 2, 212-21 (Dec. [2], 1959).

The high energy γ-ray spectra resulting from resonant neutron capture in platinum were investigated for neutron energies up to 600 eV. 63 channels of γ-ray energy and 255 of neutron time-of-flight were recorded simultaneously as binary numbers on magnetic tape giving a total of 16 000 combinations. These define the γ-ray spectra for the resonances and the background between them. The 47, 68.5 and 98 eV resonances give spectra for neutron capture in $Pt^{192}$, $Pt^{195}$ and $Pt^{198}$. These show dominant transitions which can be explained in terms of the shell model. Typical spectra for higher energy resonances are also shown. It was found that the intensity of the ground-state transition for capture in $Pt^{195}$ showed large fluctuations from resonance to resonance.

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### FLUCTUATIONS OF PARTIAL RADIATION WIDTHS OF $U^{239}$, $Hf^{178}$ AND $Pt^{196}$.

J.E.Draper and C.O.Bostrom.

Nuclear Phys., Vol. 14, No. 4, 693-5 (Jan. [2] 1960).

Partial γ-radiation widths in $U^{239}$, $Hf^{178}$ and $Pt^{196}$ (due to neutron irradiation) are shown to have significant fluctuations which are not always as large as those of the reduced neutron widths. One finds J = 1 for the 11.9 and 19.6 eV resonances of Pt.

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### GAMMA RADIATION FROM $U^{235}$ AND $Pu^{239}$ FISSION FRAGMENTS.

Yu.I.Petrov.

Atomnaya Energiya, Vol. 7, No. 2, 168-71 (1959). In Russian.

The γ radiation from $U^{235}$ and $Pu^{239}$ fission fragments at times from 0.6 s to 11 h after 1 s irradiation by thermal neutrons is studied with ionization chambers and a Geiger counter at various distances in air and water. The decay kinetics, mean γ energy (1.5 MeV) and total γ energy yield per fission are almost the same for U and Pu. The results are combined with other Russian work (unpublished) to give an expression valid for t between 0.05 s and 14 s and for r between 8.2 cm and 70 cm. The total γ energy yield per fission is expressed by four different formulae covering the period from 0.05 s to 11 h. J.B.Sykes

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### THE ENERGIES AND RELATIVE PAIR PRODUCTION CROSS SECTIONS FOR $Zn^{65}$ AND $Na^{22}$ GAMMA RAYS.

P.P.Singh, H.W.Dosso and G.M.Griffiths.

Canad. J. Phys., Vol. 37, No. 9, 1055-8 (Sept., 1959).

The following figures were obtained with a three-crystal pair spectrometer (illustrated and described): (a) gamma-ray energy: $Zn^{65}$, 1.1124 ± 0.0019 MeV; $Na^{22}$, 1.2736 ± 0.0018 MeV; (b) relative pair production cross sections: $\sigma(2.62)/\sigma(1.33) = 16.8$; $\sigma(1.33)/\sigma(1.17) = 5.1$, and $\sigma(1.17)/\sigma(1.11) = 4.22$. F.Lachman

## NUCLEAR REACTIONS

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### EXCITATION OF NUCLEI BY THE ELECTRIC QUADRUPOLE MOMENT OF THE PROJECTILE.

M.Micu.

C.R Acad. Sci. (Paris), Vol. 249, No. 14, 1208-10 (Oct. 5, 1959). In French.

This effect is evaluated; it becomes relatively important as the bombarding energy is raised. R.J.N.Phillips

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### COMPOUND NUCLEUS PROCESSES IN MEDIUM MASS NUCLEI.

A.C.Douglas and N.Macdonald.

Nuclear Phys., Vol. 13, No. 3, 382-96 (Nov. (1), 1959).

In applying compound-nucleus theory to a reaction involving many states of the compound and final nucleus, one usually assumes that the level density of the final nucleus depends on the spin I as $\rho_I \propto (2I + 1)$. This leads to the predictions that the angular distribution is isotropic and that the cross-section has the product form

$$\sigma(A + a \rightarrow B + b) = cF_{aA}F_{bB}.$$

Recent experiments on (n, p) and (n, α) reactions in nuclei of mass

$A \leq 65$ show quite strong angular anisotropies, with symmetry about 90°. The authors examined the consequences of using the more correct form

$$\rho_I \propto (2I + 1)\ \exp\{-(I + \tfrac{1}{2})^2/2\sigma^2\}.$$

Anisotropies in the direction found experimentally are predicted. The degree of anisotropy depends sensitively on $\sigma$, and the measurement of angular distributions therefore gives a means of determining this important parameter. The deviation of $\sigma(A + a \rightarrow B + b)$ from the product form is quite small.

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### 4085 THE QUASI-ELASTIC SCATTERING OF FAST PARTICLES BY ATOMIC NUCLEI.

T.K.Fowler and K.M.Watson.
Nuclear Phys., Vol. 13, No. 4, 549-75 (Nov. (2), 1959).

The scattering of fast particles by atomic nuclei for large momentum transfers and small energy loss is studied. The cross-sections may be expanded in inverse powers of the energy of the incident particle, using method due to Placzek (Abstr. 5341 of 1952) and Wick (Abstr. 7778 of 1954). The resulting cross-sections, when applied to analysis of experiments, may be used to study short-range order in nuclei. An analysis of electron, pion and proton experiments shows consistent results and also shows in a striking way the effects of the "repulsive core" in two-body forces.

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### 4086 THE MEDIUM AND HIGH ENERGY OPTICAL MODEL AND THE CORRELATIONS IN THE NUCLEAR WAVE FUNCTION.

J.Dabrowski and J.Sawicki.
Nuclear Phys., Vol. 13, No. 5, 621-41 (Nov. [3], 1959).

Watson's multiple scattering theory of the nucleon—nucleus scattering is applied to calculate the well depths of the nuclear optical potential for the case of strongly correlated nuclear matter. The nuclear ground state is represented by a Jastrow-type wave-function. The consequences of the Bethe—Goldstone equation for the correlation functions are considered. Numerical results obtained for the case of a separable nucleon—nucleon interaction show that the effects of the correlations amount to corrections to the Fermi model case up to the order of 10% in the medium and high-energy range. The evaluated corrections due to the incoherent multiple scattering appear to be important.

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### 4087 DIRECT INTERACTION WITH STRONG COUPLING IN NUCLEAR COLLISIONS.

C.B.O.Mohr.
Proc. Phys. Soc., Vol. 73, Pt 6, 894-904 (June, 1959).

For direct nuclear reactions in which there is a large probability of a particular inelastic collision, coupling between the waves in the two channels will modify the elastic and inelastic scattering as given by the distorted wave approximation. The extent of the modifications is investigated for the simplest case of E0 excitations, taking rectangular wells for the nuclear potential and the transition potential. The case of several open channels is briefly considered.

539.17 : 523.87

### NUCLEAR REACTIONS IN STARS. BUILDUP FROM CARBON.

See Abstr. 3424

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### 4088 MECHANISM OF INTERACTION OF FAST PROTONS WITH NUCLEONS AND NUCLEI.

V.S.Barashenkov, V.A.Beliakov, V.V.Glagolev, N.Dalkhazhav, Yao Tsyng Se, L.F.Kirillova, R.M.Lebedev, V.M.Maltsev, P.K.Markov, M.G.Shafranova, K.D.Tolstov, E.N.Tsyganov and Wang Shou Feng.
Nuclear Phys., Vol. 14, No. 3, 522-39 (Jan. (1), 1960).

Angular and energy characteristics of interaction between 9 GeV protons and emulsion nuclei, as well as the production of strange particles were investigated. The experimental results reveal a better agreement with the cascade mechanism of nucleon—nucleus interaction than with the nucleon-tube model. The average energy loss in a single nucleon—nucleon collision is estimated to be (40 ± 10)%. The size of a nucleon core is discussed. Through the optical analysis of nucleon—nucleon interactions the value $r_c \sim 0.6 \times 10^{-13}$ cm is obtained for the size of the nucleon core, while the fraction of peripheral collisions constitutes ~ 20%. Angular and energy distributions of slow $K^+$ and $\pi^\pm$-mesons were also obtained. The production cross-section for $K^+$-mesons with energy up to 140 MeV on an average emulsion nucleus is $\sigma = 5 \pm 2$ mb.

539.17

### 4089 ANGULAR DISTRIBUTIONS OF HIGH ENERGY PROTONS INELASTICALLY SCATTERED BY LIGHT NUCLEI.

D.J.Hooton and G.R.Allcock.
Proc. Phys. Soc., Vol. 73, Pt 6, 881-93 (June, 1959).

The effect of the central optical potential in the quasi-elastic scattering of high energy nucleons is treated by the semi-classical approximation. For non-radial excitation of the nucleus the optical potential leads to a considerable angle-independent reduction in intensity. It also produces some forward scattering when two units of orbital angular momentum are communicated to the nucleus by the scattered particle. The angular distributions for radial nuclear excitation are most seriously distorted by the optical potential; the main effect here consists in a more or less angle-independent reduction in intensity of the diffraction peaks, and the appearance of a large extra peak in the forward direction.

539.17

### 4090 A CONTRIBUTION TO THE STUDY OF ANTIPROTON ANNIHILATION IN COMPLEX NUCLEI.

A.Berthelot, C.Choquet, A.Daudin, O.Goussu and F.Lévy.
Nuclear Phys., Vol. 14, No. 3, 545-64 (Jan. (1), 1960). In French.

207 stars resulting from p annihilation were analysed. Results are given concerning the mean free path for annihilation as well as the main characteristics of annihilation stars. The proportion of sta which are effectively accompanied by at least one visible K-meson was (4.6 ± 0.5)%. The error quoted does not take into account the statistical uncertainty. The average numbers are compared with the latest Berkeley results.

539.17

### 4091 $C^{12}(p, 2p)B^{11}$ IN THE IMPULSE APPROXIMATION.

K.F.Riley.
Nuclear Phys., Vol. 13, No. 3, 407-19 (Nov. (1), 1959).

The cross-section for $C^{12}(p, 2p)B^{11}$ is calculated on the basis of the impulse approximation using a W.K.B. method, in which absorption is taken into account. The effects of reflection and refraction are discussed, and the former is treated approximately. The effect of finite energy resolution on the observed angular distribution of the two protons is found.

539.1

### 4092 ELASTIC AND INELASTIC SCATTERING OF 11 MeV PROTONS ON $Zn^{64}$, $Zn^{66}$ $Zn^{68}$ ISOTOPES.

R.Beurtey, P.Catillon, R.Chaminade, H.Faraggi, A.Papineau and J.Thirion.
Nuclear Phys., Vol. 13, No. 3, 397-406 (Nov. [1], 1959). In French.

The elastic and inelastic scattering of 11 MeV protons on separated isotopes of zinc ($Zn^{64}$, $Zn^{66}$, $Zn^{68}$) is described. The elastic scattering curves exhibit differences which will be compared with theoretical curves in a later article. Inelastic spectra with good resolution were studied and the curves corresponding to the first excited state were obtained.

539.17

### 4093 THE TOTAL PROTON REACTION CROSS SECTION OF CARBON FROM 10-68 MeV BY A NEW METHOD.

E.J.Burge.
Nuclear Phys., Vol. 13, No. 4, 511-15 (Nov. (2), 1959).

Inelastic interactions in scintillators produce a low energy tail in the pulse height spectrum. The fractions of pulses in the tails for protons of various energies are used directly to determine the total reaction cross-section as a function of energy. The method applies only to nuclei in scintillators. Results for carbon are presented for 10-68 MeV.

539.17

### 4094 THE NUCLEAR SCATTERING OF 970 MeV PROTONS BY CARBON.

G.Z.Shah and K.M.Gatha.
Curr. Sci., Vol. 28, No. 9, 361-2 (Sept., 1959).

Optical model analysis of the results of Batty and Goldsack (Abstr. 5406 of 1957). However, see Abstr. 2782 (1959) for a discussion of these results.

C.J.Batty

539.17 : 539.14

### LEVELS OF $P^{29}$ FROM $Si^{28}(p,p)Si^{28}$ AND $Si^{28}(p,p')Si^{28*}$.

See Abstr. 4032

539.17

### 4095 DISINTEGRATION OF HAFNIUM BY 660 MeV PROTONS

A.K.Lavrukhina and A.A.Pozdnyakov.
Atomnaya Energiya, Vol. 7, No. 4, 382-4 (1959). In Russian.

The products were separated chromatographically and the ope yield curves constructed. These are similar to results viously obtained for copper, but shifted towards neutron-cient nuclei (67% of the cross-section as against 40%). The 1 disintegration cross-section is 1.5 × $10^{-24}$ cm$^2$ = 85% of the metrical cross-section. The mean numbers of neutrons and tons emitted and evaporated are tabulated for hafnium and per. J.B.Sykes

539.17

### 4096 NEUTRONS FROM THE PROTON BOMBARDMENT OF $Li^6$ AND $Li^7$.

jzenberg-Selove, C.F.Osgood and C.P.Baker.
s. Rev., Vol. 116, No. 6, 1521-5 (Dec. 15, 1959).

This is the fourth in a series of papers describing studies of level structure of the $T_Z = -1$ [$T_Z = N - Z/2$] nuclei. Previous k dealt with $C^{10}$ (Abstr. 11391 of 1954), $N^{12}$ (Abstr. 1966 of 1958), $O^{14}$ (Abstr. 6879 of 1954). The $Li^7(p,n)Be^7$ and $Li^6(p,n)Be^6$ reas were studied at $E_p$ = 10.5 MeV, by the method of proton recoils uclear emulsions. The $Li^7(p,n)Be^7$ spectra at 30° and 90° show known states of $Be^7$ at 0, 0.43, and 4.53 MeV. The cross-tion for formation of the ground state at 90° (lab) is 3.2 mb/sterad 0%). The $Li^6(p,n)Be^6$ spectra at 30°, 60°, 90°, and 135° show und-state groups with Q = −5.05 ± 0.2 MeV. This leads to − A) for $Be^6$ = 20.13 ± 0.2 MeV. $Be^6$(0) is thus unbound with pect to ($He^4$ + 2p) by 1.35 MeV. The cross-section for formation $Be^6$(0) at 90° (lab) is 0.5 mb/sterad (±30%). At 90°, there is also ication of a sharp excited state at $E_X$ = 1.5 ± 0.2 MeV. The lifees of $Be^6$(0) and Be (1.5 MeV) are $>\sim 4 \times 10^{-21}$ sec and × $10^{-21}$ sec, respectively. These results are discussed in ms of the other available information on the A = 6 isobars.

539.17

### 4097 RESONANCE ENERGIES FOR PROTON CAPTURE. I. MAGNESIUM.

S.Wagner and M.Heitzmann.
Naturforsch., Vol. 14a, No. 9, 784-6 (Sept., 1959). In German.

Determines the resonance energies for proton capture in the ural isotopes of magnesium as follows:

$^{24}(p,\gamma)Al^{25}$ : (223.0 ± 0.5), (419.1 ± 0.7) keV;
$^{25}(p,\gamma)Al^{26}$ : (316.1 ± 0.5), (389.3 ± 0.7), (434.6 ± 0.8), (496.5 ± 0.8), (514.8 ± 0.8), (567.2 ± 0.7), (591.9 ± 0.7), (685.2 ± 1.0) keV;
$^{26}(p,\gamma)Al^{27}$ : (292.2 ± 0.8), (338.1 ± 0.5), (453.8 ± 0.5), (662.1 ± 1.0) keV.

e experimental resonance half-widths are of the order of 200 to eV. S.J.St-Lorant

539.17 : 539.14

### 4098 PROPERTIES OF [COMPOUND NUCLEUS] LEVELS EXCITED IN (p, α) REACTIONS ON $O^{18}$, $P^{31}$, $Cl^{35}$, $Cl^{37}$, $K^{39}$ ND $K^{41}$.

R.L.Clarke, E.Almqvist and E.B.Paul.
clear Phys., Vol. 14, No. 3, 472-97 (Jan. (1), 1960).

Excitation functions and differential cross-sections at 90° to the am were measured for the (p, α) ground-state reactions in $O^{18}$, $P^{31}$, $^{35}$, $Cl^{37}$, $K^{39}$ and $K^{41}$ for 1-3 MeV proton energy using a magnetic spectro-eter to detect the alpha-particles. Reduced widths and strength nctions for protons and alpha-particles are derived; the alpha-partle strength functions are a factor of five smaller than the proton lues which agree with published results of (p, n) studies in the ass 40 region. The reduced widths of protons and alpha-particles units of $\hbar^2/\mu R^2$ are both 3 × $10^{-2}$ for $P^{31}$ and decrease to 0.4 × $10^{-2}$ ear mass 40. The equality of the proton and alpha-particle reduced idths suggests that these particles appear on the nuclear surface ith equal probability. The measured mean level spacing of compound nuclei ($F^{19}$, $S^{32}$, $A^{36}$, $A^{38}$, $Ca^{40}$, $Ca^{42}$ respectively) runs from keV for $S^{32}$ to < 15 keV in the mass 40 region. These are larger an is predicted by the semi-empirical level spacing equation of ameron. The measured Q-values of the (p, α) reaction are

$$Cl^{35} = 1.865 \pm 0.015 \text{ MeV}, \quad Cl^{37} = 3.015 \pm 0.015 \text{ MeV},$$
$$K^{39} = 1.267 \pm 0.020 \text{ MeV}, \quad K^{41} = 4.002 \pm 0.020 \text{ MeV}.$$

539.17

### 4099 ON DIFFRACTIONAL DISINTEGRATION OF DEUTERONS.

A.G.Sitenko and V.K.Tartakovsky.
uclear Phys., Vol. 13, No. 3, 420-34 (Nov. (1), 1959).

Diffraction disintegration of deuterons in nuclei is considered nder the assumption that the radius of the deuteron is appreciably ess than that of the nucleus. A differential cross-section of the rocess is determined, giving the energy distribution of the disntegration products in the deuteron's centre-of-mass system and in the laboratory system, their angular distribution, the momentum distribution of the recoil nuclei, and the angular correlation between the disintegration products. The polarization of these particles is also considered.

539.17

### 4100 REACTION $C^{12}(d,n)N^{13}$.

A.Elwyn, J.V.Kane, S.Ofer and D.H.Wilkinson.
Phys. Rev., Vol. 116, No. 6, 1490-8 (Dec. 15, 1959).

The reaction has Q = −0.28 MeV and so is expected to show strong direct interaction effects even at low energies of the bombarding deuterons. An extensive study of this reaction was made at 14 values of the deuteron energy between 1.45 and 2.95 MeV. At each deuteron energy the differential cross-section was measured at about 20 angles between 0° and 165°. Neutron time-of-flight techniques were used and each point on each angular distribution represents the detection of at least $10^3$ neutrons. Direct interaction effects are seen at all bombarding energies in the backward as well as in the forward hemisphere. The differential cross-section at 0° shows very pronounced "resonance" structure but this largely disappears in the integrated cross-section and is due chiefly to interference between the direct interaction term and the probably quite small compound nucleus contribution. A rough method for eliminating the interference terms between the two mechanisms in the differential cross-section is proposed and applied. The resultant "purified" angular distribution is remarkably close, in the forward hemisphere, to that predicted by simple stripping theory. A backward maximum, much lower than the forward peak, is also present but not accounted for.

539.17 : 539.14

$Ca^{40}(d,n)Sc^{41}$: LOW-LYING ENERGY LEVELS IN $Sc^{41}$. See Abstr. 4033

539.17

### 4101 $Cl^{35}(d, p)Cl^{36}$ IN THE UNIFIED MODEL.

M.L.Mehta and C.S.Warke.
Nuclear Phys., Vol. 13, No. 3, 451-5 (Nov. (1), 1959).

The general expression for the angular distribution of protons derived from Sawicki's transition matrix elements is given. The angular distribution of protons in the reaction $Cl^{35}(d, p)Cl^{36}$ is calculated assuming the strong coupling unified model. Calculation of the integral in the stripping formula takes into account the effect of the deformed surface of the nucleus. The value of the deformation obtained from fitting the observed angular distribution is found to agree roughly with those derived from the quadrupole and magnetic moments.

539.17

### 4102 DIFFERENTIAL CROSS SECTIONS FOR THE $Be^9(He^3,p)B^{11}$ REACTION.

E.A.Wolicki, H.D.Holmgren, R.L.Johnston and E.G.Illsley.
Phys. Rev., Vol. 116, No. 6, 1585-91 (Dec. 15, 1959).

The differential cross-sections for the six highest energy proton groups from the $Be^9(He^3,p)B^{11}$ reaction were measured as a function of angle at a bombarding energy of 4.5 MeV. For the five highest energy groups, the cross-sections are largest in the forward direction and are not symmetric about 90°. For all six proton groups, yields observed at large angles to the incident beam direction are comparable to the forward yields. A strong maximum in the backward direction is observed for the third excited state proton group. At 4.5 MeV, the total cross-sections are 11.5 mb for the ground-state proton and 7.4 mb for the first excited state proton group. For the proton groups leaving $B^{11}$ in the ground and first excited states, differential cross-sections were measured at six angles as a function of bombarding energy in the range from 1.8 to 5.0 MeV. In each case, the total cross-section for the reaction shows no resonances. The change in the angular distributions which may be inferred from these yield curves is seen to proceed in a gradual manner with increasing bombarding energy. Differential cross-sections for the second and third excited state proton groups were measured at 7° and 90° in the bombarding energy interval from 3.0 to 5.0 MeV. The observed characteristics for this reaction taken together indicate that direct interactions are important.

539.17

### 4103 CROSS SECTIONS AND ANGULAR DISTRIBUTIONS FOR THE $B^{10}(\alpha,d)C^{12}$ REACTION FROM 3.2 MeV TO 3.8 MeV.

K.Ono and K.Kuroda.
Phys. Rev., Vol. 117, No. 1, 214-15 (Jan. 1, 1960).

This reaction was studied in order to investigate the possibility of direct interactions in (α,d) reactions. The yield curves are rather flat and show no typical resonance structures. The angular distributions show a peak at about $\theta = 70^{\circ}$(c.m.) and an increase of intensity in the backward direction over the entire alpha-particle energy range. These results indicate that the $B^{10}(\alpha,d)C^{12}$ reaction proceeds mostly by direct processes, probably both stripping (or knock-on) and heavy-particle stripping ones.

539.17 : 537.54

### COULOMB EXCITATION OF Ta, Au, Pt, Pb, BY $\alpha$-PARTICLES.

See Abstr. 3821

539.17

### 4104 NUCLEAR FRAGMENTS PRODUCED IN THE HEAVY ION BOMBARDMENT OF ALUMINUM.

C.E.Anderson, W.J.Knox, A.R.Quinton and G.R.Bach.
Phys. Rev. Letters, Vol. 3, No. 12, 557-9 (Dec. 15, 1959).

Products leaving the target at a defined angle to the incident beam were passed through a thin proportional counter which measured dE/dx and then into a CsI scintillator which measured the energy E. A photographic record was made of a display on a plotting oscillograph showing dE/dx as a function of E. Points were then distributed in a series of curves corresponding to different values of Z, from which the number and energy distribution of each element from He to F among the reaction products could be seen. The results for various angles are discussed, one important result being that the stable isotope yield is of the order of 100 times the radioactive isotope yield. J.H.Fremlin

539.17

### 4105 RANGES AND ENERGY-LOSS PROCESSES OF HEAVY IONS IN EMULSION.

H.H.Heckman, B.L.Perkins, W.G.Simon, F.M.Smith and W.H.Barkas.
Phys. Rev., Vol. 117, No. 2, 544-56 (Jan. 15, 1960).

The range-energy relations for C, N, O, Ne and A ions in nuclear-track emulsion were measured for energies up to 10 MeV/nucleon. The ions, accelerated by a heavy-ion linear accelerator, were suitably degraded and subsequently analysed by a 180° double-focusing magnetic spectrometer. The heavy-ion ranges were measured relative to those of $\alpha$-particles which were employed to calibrate the instrument. Within the energy interval studied, it was found that a general expression for the range of a heavy ion is

$$R = (M/z^2)\lambda(\beta) + Mz^{2/3}C_Z(\beta/z),$$

where $\lambda(\beta)$ is the range of a particle of proton mass and charge at velocity $\beta c$, $C_Z(\beta/z)$ is an empirical function that corrects for the extension in range caused by neutralization of the ionic charge as electrons are captured at low velocities, and M and z are the ionic mass and charge in units of the proton. The range data are sufficiently complete and accurate to allow detailed analyses of rates of energy loss and effective charge of the heavy ions as they come to rest. The relative importance of primary and secondary ionization processes in producing the taper in the track of a multicharged ion was studied by examining the ions in emulsions of various sensitivities. Buckling-type distortions of heavily ionizing tracks in strongly developed emulsions are also discussed. The range-energy relation for low-velocity protons is re-examined and an improved range point at 0.585 MeV is reported.

539.17

### 4106 MECHANISM OF TRANSFER REACTIONS WITH HEAVY IONS. A.Zucker.

Phys. Rev. Letters, Vol. 4, No. 1, 21-3 (Jan. 1, 1960).

A summary is given of experiments carried out in a number of laboratories on the transfer of nucleons in heavy ion reactions. It is pointed out that, while the cross-section for transfer of two neutrons is around one hundreth of that for transfer of one, the cross-section for apparently more complex transfers such as the loss of 2p3n are comparable with those for one neutron. It is suggested that in fact in such cases a single nucleon transfer may leave donor or acceptor nucleus in an excited state permitting the emission of a free $\alpha$-particle. The spread in range of $N^{13}$ and $C^{11}$ from $O^{16}$ + Sn, as compared to that of $O^{18}$, could be due to $\alpha$ recoil and thus supports the hypothesis. J.H.Fremlin

539.17

### 4107 COULOMB EXCITATION OF NUCLEI BY $Li^6$ AND $Li^7$ PROJECTILES. C.S.Littlejohn and G.C.Morrison.

Phys. Rev., Vol. 116, No. 6, 1526-34 (Dec. 15, 1959).

In order to examine the characteristics of lithium-ion-induced Coulomb excitation, and to extend the cross-section ratio technique for the determination of the multipolarity of transitions, a study was made of the $\gamma$-rays emitted following electric excitation of several different target nuclei by $Li^6$ and $Li^7$ ions in the energy range 1.1 to 2.2 MeV. Measurements were made of thick-target yields of the 110 keV (E1) and 198 keV (E2) $\gamma$-rays from $F^{19}$, the 128 keV (E2) $\gamma$-ray from $Mn^{55}$, and the 160 keV (E2) $\gamma$-ray from $Ti^{47}$ and compared with yields calculated from the theoretical cross-sections. The yields of the $\gamma$-rays studied were observed to increase with beam energy in the manner predicted by theory for electric dipole or electric quadrupole excitation. The ratios of the $Li^6$ and $Li^7$ induced yields at corresponding (equal $\xi$) energies for E1 and E2 transitions after correction for range effects were found to agree, within the estimated errors, with the theoretical predictions for cross-section ratios.

539.17

### 4108 ANGULAR DISTRIBUTION OF $Li^8$ FROM $Be^9(Li^7,Li^8)Be^8$

E.Norbeck, J.M.Blair, L.Pinsonneault and R.J.Gerbracht
Phys. Rev., Vol. 116, No. 6, 1560-2 (Dec. 15, 1959).

Angular distribution curves and an excitation curve are given for $Li^8$ produced by the reaction $Be^9(Li^7,Li^8)Be^8$ with $Li^7$ beam energies between 2.0 and 4.0 MeV. The angular distribution may be roughly approximated by $\sin^2\theta$ in the centre-of-mass system, with the central peak shifting forward as the energy is increased. The total cross-section for the production of $Li^8$ increases with energy with no indication of resonances.

539.17 : 539.14

### EXCITED STATES OF $B^{13}$, FROM $Li^7(Li^7,p)B^{13}$.

See Abstr. 4023

539.17

### 4109 NEUTRON YIELDS FROM TARGETS BOMBARDED BY ELECTRONS. W.C.Barber and W.D.George.

Phys. Rev., Vol. 116, No. 6, 1551-9 (Dec. 15, 1959).

The total neutron yields from thick targets bombarded by electrons were measured as a function of electron energy for the range 10 to 36 MeV. Targets ranging in thickness from one to six radiation lengths of C, Al, Cu, Ta, Pb, and U were used. The yields for 1- and 6-radiation-length targets of Pb at 34 MeV are $2.1 \times 10^{-3}$ and $9.0 \times 10^{-3}$ neutrons/electron. Extrapolation to infinite target thickness gives a value of $9.5 \times 10^{-3}$ neutron/electron. The yield, comparing targets of one radiation length, from C is about 10 times smaller and that from U two times greater than the yield from Pb. An explanation of the relative Z-dependence of the yield in terms of known photonuclear cross-sections is successful to within a factor of 1.5. The absolute accuracy of the results is estimated to be ±15%. Calibration of the neutron-detecting equipment was made with a RaBe source and checked by measuring the yields, due to electro- and photodisintegration of the deuteron, from a heavy-water target. In addition, yields from thin targets of Be and Cu were observed as a function of electron energy. The data for Be yield a value of (0.018 ± 0.003) MeV barn for the $(\gamma,n)$ cross-section integrated to 17 MeV. The data for Cu were analysed and combined with other measurements to give an approximate cross-section for the $Cu(\gamma,pn)$ reaction.

539.17

### 4110 THE ELECTRIC DIPOLE SUM RULE.

G.I.Opat.
Nuclear Phys., Vol. 14, No. 3, 506-11 (Jan. [1], 1960).

A derivation of the electric dipole sum rule (used in analysis of photonuclear reactions) is given, which takes nuclear recoil into account and eliminates redundant coordinates.

539.17

### 4111 THE PHOTONUCLEAR REACTIONS AND THE GIANT RESONANCE. II. ENERGY AND ANGULAR DISTRIBUTIONS OF PHOTONEUTRONS AND PHOTOPROTONS AND FINE STRUCTURE OF THE GIANT RESONANCE. V.De Sabata.

Nuovo Cimento Suppl., Vol. 11, No. 2, 225-309 (1959). In Italian.

A short critical introduction precedes a complete survey of the experimental material available at present on the subject. Particular emphasis is given to results on energy and angular distributions. Work on photodisintegration of the deuteron and photofission are deliberately omitted from this survey. The present paper complements a previous one (see Abstr. 9811 of 1957) in which the various theories and nuclear models were critically examined. G.Martelli

539.17

### 4112 THE GIANT RESONANCE OF PHOTODISINTEGRATION OF TANTALUM.

.M.Spicer, H.H.Thies, J.E.Baglin and F.R.Allum.
Austral. J. Phys., Vol. 11, No. 3, 298-309 (Sept., 1958).

The neutron yield has been measured as a function of bremsstrahlung energy, and from this the shape of the cross-section for the nuclear absorption of photons by tantalum has been deduced. This cross-section shows definite evidence that it is made up of two component parts. The result is in agreement with the theoretical predictions of Danos (Abstr. 6322 of 1958) for this nucleus, both regarding the existence of the two components and the energy separation of the two peaks. Using the Danos theory, the intrinsic electric quadrupole moment for tantalum is calculated to be 6.1 barns ±10%.

539.17 : 539.14

### EXCITED STATES OF OXYGEN USING THE (γ, n) REACTION.

See Abstr. 4034

539.17

### 4113 A NOTE ON S-WAVE AVERAGE NEUTRON CROSS SECTIONS.

K.K.Seth.
Canad. J. Phys., Vol. 37, No. 10, 1199-202 (Oct., 1959).

An approximation is introduced for the average cross-section for s-wave neutrons, based on a square-edged optical well. It is shown to be much more accurate than an approximation of Lane and Lynn (1957), over a range of energies up to 0.5 MeV. J.A.Evans

539.17

### 4114 VARIATIONAL PRINCIPLE IN THE OPTICAL MODEL FOR NUCLEAR REACTIONS DUE TO NEUTRONS.

.Brănduş.
Rev. de Physique (Bucarest), Vol. 4, No. 2, 255-62 (1959).
In French.

Proposes to calculate scattering phase shifts for a complex central well by a variational method. R.J.N.Phillips

539.17

### 4115 ATLAS OF γ-RAY SPECTRA FROM RADIATIVE CAPTURE OF THERMAL NEUTRONS.

L.V.Groshev, V.N.Lutsenko, A.M.Demidov and V.I.Pelekhov.
Translated from the Russian by J.B.Sykes.
London, New York, Paris, Los Angeles: Pergamon Press (1959)
198 pp. [International Series of Monographs on Nuclear Energy, Division IV, Vol. 1].

A compilation in tabular and graphical form for more than 50 capturing elements, taken from results published by laboratories in many countries. Nuclear level schemes are given for many of the nuclei formed by neutron capture. Results for 19 elements obtained with the magnetic Compton spectrometer are included; also information on low-energy gamma-lines in the nuclei Cu$^{64\ 66}$, In$^{116}$, Ag$^{108\ 110}$ obtained with scintillation spectrometers. There are two appendices, which contain data on conversion electrons emitted in thermal neutron capture, and on gamma-rays from radioactivity which appear in γ-spectra from the (n,γ) reaction.

539.17

### 4116 GAMMA RADIATIONS FROM INELASTIC SCATTERING OF FAST NEUTRONS IN C$^{12}$, N$^{14}$ AND O$^{16}$.

H.E.Hall and T.W.Bonner.
Nuclear Phys., Vol. 14, No. 2, 295-313, (Dec. (2), 1959).

Measurements were made of the cross-section for the production of 4.43 MeV γ-radiation by the inelastic scattering of neutrons by C$^{12}$. The experiments were carried out using monoenergetic neutrons with energies of from 4.6 to 9.8 MeV. Ten resonances were observed in this energy range and the maximum cross-section of 45 mb/sr was obtained at a neutron energy of 8.1 MeV. Measurements made with an O$^{16}$ scatterer also showed many resonances for the production of γ-radiation with energies of 6.14, 6.91 and 7.12 MeV. The maximum cross-section for γ-emission was obtained with 9.1 MeV neutrons and amounted to 30 mb/sr. Population of the 6.06 MeV pair emitting state in O$^{16}$ was not observed and an upper limit on the probability of exciting this state was less than 10% of that for the excitation of the γ-emitting states. Gamma-radiations from the interaction of fast neutrons in N$^{14}$ were observed with neutrons of energies from 4.7 to 8.1 MeV. Gamma-radiations with energies of 1.64, 2.14, 2.31, 4.46 and 5.06 MeV were observed. Approximately half of the cross-section for the production of γ-radiation is from the $N^{14}(n, \alpha)B^{11*}$ reaction and the rest is from inelastic scattering in N$^{14}$. At a neutron energy of 7.3 MeV the cross-section for the $N^{14}(n, n'\gamma)N^{14}$ reaction, including cascades, is 16.2 mb/sr and the cross-section of the $N^{14}(n, \alpha)B^{11*}$ reaction, leading to the first three excited states, is 10.7 mb/sr.

539.17

### 4117 CASCADE γ TRANSITIONS IN Cl$^{36}$ ACCOMPANYING THERMAL NEUTRON CAPTURE.

V.R.Burmistrov.
Atomnaya Energiya, Vol. 7, No. 3, 260-2 (Sept., 1959). In Russian.

Measurements by a coincidence method using scintillation counters, with corrections for chance and spurious coincidences, gave information on six γ cascades in Cl$^{36}$. J.B.Sykes

539.17 : 539.1.07

### 4118 EXCITATION STUDY OF $F^{19}(n,\alpha)N^{16}$ WITH A BaF$_2$ CRYSTAL.

D.M.Smith, N.A.Bostrom and E.L.Hudspeth.
Phys. Rev., Vol. 117, No. 2, 514-16 (Jan. 15, 1960).

The scintillation properties of crystalline BaF$_2$ were investigated. It was found that this substance yields a reasonably well-defined photopeak when exposed to gamma rays from Na$^{22}$. With DuMont K1306 and 6292 photomultipliers, the signals from BaF$_2$ are about $\frac{1}{5}$ to $\frac{1}{10}$ as strong as those from NaI(Tl). With a BaF$_2$ crystal as a target, the excitation function for the $F^{19}(n,\alpha)N^{16}$ reaction was observed in the region from an apparent threshold near 3.2 MeV up to $E_n = 6$ MeV. Several new resonances were found in this region. The cross-section generally increases with increasing neutron energy, rising from 85 mb at 4.48 MeV to 200 mb near 6 MeV. Absolute accuracy of cross-section measurements was ±15%.

539.17

### 4119 MEASUREMENTS OF THE FAST NEUTRON RADIATIVE CAPTURE CROSS-SECTIONS OF GALLIUM ISOTOPES.

Yu.Ya.Stavisskii and V.A.Tolstikov.
Atomnaya Energiya, Vol. 7, No. 3, 259 (Sept., 1959). In Russian.

Fast neutron radiative capture cross-sections of Ga$^{69}$ and Ga$^{71}$ are measured by comparison of the activity induced by irradiation with fast and thermal neutrons with I$^{127}$ as standard. That of Ga$^{69}$ varies smoothly, but that of Ga$^{71}$ falls sharply near 550 keV owing to competition from inelastic scattering. J.B.Sykes

539.17

### 4120 THE DISINTEGRATION OF NITROGEN BY FAST NEUTRONS.

F.Gabbard, H Bichsel and T.W.Bonner.
Nuclear Phys., Vol. 14, No. 2, 276-94 (Dec. (2), 1959).

The disintegration of nitrogen by fast neutrons was studied using a grid-type ionization chamber filled with nitrogen-argon mixture. Monoenergetic neutrons for studying the reactions at neutron energies of 1.3 to 8.2 MeV were produced by the $T^3(p, n)He^3$ and $D(d, n)He^3$ reactions. One group of protons, three alpha-particle groups, and a group of tritons were observed as disintegration products of the neutron reactions in nitrogen. The $N^{14}(n, p)C^{14}$ reaction, leaving C$^{14}$ in its ground state, was studied from 1.3 to 4.3 MeV and the maximum cross-section observed was 230 mb. Four groups of α-particles leading to the ground, 2.14, 4.46, and 5.03 MeV levels in B$^{11}$ were observed in the experiment. The cross-section for the α-particle group leading to the ground state of B$^{11}$ varied from 5 mb at a neutron energy of 1.3 MeV to 390 mb at 4.2 MeV and decreased for higher neutron energies. Triton emission leading to the ground state of C$^{12}$ was observed above a neutron energy of 5.6 MeV. Above 7 MeV, the cross-section for disintegration by emission of each of the alpha-groups and by triton emission were about equal and were approximately 40 mb. The cross-sections show many narrow resonances in the neutron energy range studied. The data show that alpha emission relative to proton and neutron emission from these highly excited states of N$^{15}$ is much more probable than expected on shell-model considerations.

539.17 : 539.14

### 4121 INELASTIC NEUTRON SCATTERING IN Nb$^{93}$.

N.Nath, M.A.Rothman, D.M.Van Patter and C.E.Mandeville.
Nuclear Phys., Vol. 14, No. 1, 78-96 (Dec. [1], 1959).

Study of gamma-ray spectra following inelastic neutron scattering in Nb$^{93}$ was made at bombarding energies ranging from 0.81 to 2.25 MeV. Measurement of thresholds for the gamma-rays and the gamma–gamma coincidence spectra made it possible to work out a level scheme for Nb$^{93}$. The energies of the two levels previously reported were revised to 0.741 and 0.958 MeV. In addition, levels were found at 0.809, 1.08, 1.28, 1.34, 1.48, 1.67 and 1.92 MeV. In all, fourteen gamma-ray transitions were detected and the possibility of a few more is indicated. In suitable cases, branching ratios were calculated. Gamma-ray production cross-sections were also tabulated. Theoretical calculations of the cross-sections for the first five levels, using a diffuse-edge potential well, give fairly good agreement with the experiment. Probable spin assignments for the second to fifth excited states are discussed.

539.17

### 4122 THE DISINTEGRATION OF $Ne^{20}$ BY FAST NEUTRONS.

R.J.Bell, T.W.Bonner and F.Gabbard.

Nuclear Phys., Vol. 14, No. 2, 270-6 (Dec. (2), 1959).

The cross-section for the $Ne^{20}(n, \alpha)O^{17}$ reaction was measured for neutron energies between 2.8 and 7.3 MeV. The (n, α) disintegrations were detected in a grid-type ionization chamber filled with neon. The cross-section for this reaction varies between 10 and 270 millibarns in this energy range and shows many narrow resonances. Disintegrations were observed leaving $O^{17}$ in the ground state and in the first three excited states.

539.17

### 4123 THE TOTAL NEUTRON CROSS-SECTION OF $Ra^{226}$.

M.I.Pevzner, L.S.Danelyan and Yu.V.Adamchuk.

J. nuclear Energy, Vol. 4, No. 3, 366-70 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4, 67 (1956).

The total cross-section of radium has been measured with a mechanical velocity selector between 0.022 and 50 eV. A resonance is found at E = 0.537 ± 0.006 eV whose parameters, calculated with allowance for Doppler broadening and instrumental resolution, are $\sigma_0 = 3600 \pm 150$ barns, $\Gamma = 0.029 \pm 0.001$ eV, and $\Gamma_n = 2.1 \pm 0.1 \times 10^{-5}$ eV.

539.17

### 4124 RADIATIVE CAPTURE OF SLOW NEUTRONS BY ATOMIC NUCLEI.

J. Urbanec, J.Kopecký and J.Kajfosz.

Czech. J. Phys., Vol. 9, No. 5, 544-51 (1959). In Russian.

The energies and absolute intensities of gamma radiation from the capture of thermal neutrons by $S^{33}$, $Cl^{36}$, $K^{40}$, $Ca^{41}$, $V^{52}$, $Mn^{56}$ and $Hg^{200}$ were measured by means of a simple crystal scintillation spectrometer. The transitions in the energy interval 100-1200 keV are mostly transitions between the lowest excited states of the nuclei.

539.17

### 4125 THE PILE-NEUTRON ABSORPTION CROSS-SECTION OF SAMARIUM-149.

K.L.Aitken, D.J.Littler, E.E.Lockett and G.H.Palmer.

J. nuclear Energy, Vol. 4, No. 1, 33-7 (Jan., 1957).

The pile-neutron absorption cross-section of natural samarium has been determined as 10 380 (±160) barns by making a comparison with boron in the GLEEP oscillator. Irradiation of a natural-samarium sample in the reflector in the NRX pile in Canada, and subsequent measurement of the change in its isotopic composition show that samarium-149 is the only significant contributor to the thermal-neutron absorption cross-section. Applying a small correction for epithermal absorption in 147 and 152 isotopes, the pile-neutron absorption cross-section of samarium-149 is deduced to be 74 500 (±1100) barns.

539.17 : 539.18

### 4126 TOTAL NEUTRON CROSS SECTION OF XENON AND KRYPTON.

D.P.Mann, W.W.Watson, R.E.Chrien, R.L.Zimmerman and R.B.Schwartz.

Phys. Rev., Vol. 116, No. 6, 1516-20 (Dec. 15, 1959).

By the thermal diffusion method, using 12 metres of hot-wire columns, concentrations of the xenon isotopes in good quantity (about 57% $Xe^{129}$ in the light fraction and 27% $Xe^{136}$ in the heavy one) were produced without recycling. A fair-sized sample of "light" krypton, analysing better than 50% $Kr^{80}$, was available from earlier thermal diffusion separation with recycling by Blais and Watson. These samples together with the normal gases were concentrated to thicknesses of about 3.3 g/cm² in special gas target holders for use with the Brookhaven fast chopper. For krypton, neutron widths and isotopic identifications were determined for the following levels: 27.9 eV in $Kr^{83}$, 39.8 eV in $Kr^{82}$, 106 eV in $Kr^{80}$, 233 eV in $Kr^{83}$, 519 eV in $Kr^{84}$, 580 eV in $Kr^{84}$ and 640 eV in either $Kr^{78}$ or $Kr^{80}$. Total widths and radiation widths were obtained for the 27.9 and 106 eV levels by thick-thin area analysis. For xenon, new resonances are observed at 5.2 eV in $Xe^{124}$, 9.5 eV in $Xe^{129}$, 14.1, 46.0 and 76.0 eV all in $Xe^{131}$, 92.0 eV in $Xe^{129}$, and 126 eV to be assigned to either the 128, 129, or 130 isotope.

539.17

### 4127 DIFFERENTIAL ELASTIC SCATTERING OF 14 MeV NEUTRONS BY Zn, Sn, Sb, Pb, AND Bi.

L.A.Rayburn.

Phys. Rev., Vol. 116, No. 6, 1571-4 (Dec. 15, 1959).

Differential elastic scattering cross-sections were measured in the angular interval from 10° to 165°. The experimental measurements are corrected for multiple scattering and the finite angular resolution by Monte Carlo methods. The corrected cross-sections are compared with theoretical values computed by use of a comple potential with a spin-orbit term.

539.1

### 4128 ON EXCITATION OF NUCLEI BY μ-MESONS.

D.F.Zaretsky and V.M.Novikov.

Nuclear Phys., Vol. 14, No. 3, 540-4 (Jan. (1), 1960).

Excitation of heavy nuclei in μ-mesic atom 2p—1s transitions is considered. The effect is connected with the electromagnetic interaction between the meson and nucleus. The ratio of the probability of emission of a γ-quantum during the indicated transition to the probability of transfer of all the transition energy to the nucleu with subsequent dissipation of the energy through nuclear channels is computed. The case is considered when the distance between the nuclear levels is much greater than the width of the levels for the indicated excitation energy.

539.1

### 4129 ABSORPTION OF MUONS IN CARBON 12 AND THE UNIVERSAL FERMI INTERACTION.

J.D.Teja.

Arch. Sci. (Geneva), Vol. 12, No. 2, 131-215 (1959). In French.

An account is given of an experimental study of the ratio of the strengths of μ—nucleon and electron—nucleon interactions. This ratio should be unity in the universal Fermi theory. $\mu^-$-mesons are stopped in carbon and the probability $P_\mu$ for the ground state transitions in the reactions $\mu^- + C^{12} \rightarrow B^{12} + \nu$ measured. With a correction of 10% for the possible formation of excited states, $P_\mu = (8.9 \pm 0.5) \times 10^3\ sec^{-1}$. The rate of beta decay of $B^{12}$ to the ground state of $C^{12}$ is found to be $P_\beta = (32.64 \pm 0.65)\ sec^{-1}$. $P_\beta$ is known with fair accuracy from previous experiments, and the ratio found is $P_\mu/P_\beta = 273 \pm 13$. Theoretical estimates of $P_\mu$ are made, all calculations assuming the equality of the strengths of the interactions. The values of $P_\mu$ are grouped around $P_\mu = (8.00 \pm 2.0) \times$ $\times 10^3\ sec^{-1}$. The good agreement of theory with experiment seems to indicate that the strengths of the electron—nucleon and μ—nucleo interactions are equal to within the uncertainties inherent in the methods employed. S.J.St-Loran

539.

### 4130 MUON CAPTURE BY $C^{12}$ AND BETA DECAY OF $B^{12}$.

G.Flamand and K.W.Ford.

Phys. Rev., Vol. 116, No. 6, 1591-6 (Dec. 15, 1959).

The finite size of the carbon nucleus causes the K-orbit muon density within the nucleus to be smaller than the density for a poin nucleus. Previously calculated muon capture rates in carbon shoul be reduced by about 6% for this effect. The recalculated capture rate to the ground state of $B^{12}$ does not differ greatly from previous calculated values. It is 7300 $sec^{-1}$, with an assigned theoretical error of about 10%. The result tends to support the Feynman—Gell-Mann proposal of a conserved vector current in the framework of a universal Fermi interaction. Various predicted correlat coefficients are also given; these do not differ significantly from those of Wolfenstein. The allowed and all second-forbidden matrix elements were calculated as a function of the intermediate coupling parameter a/K. The beta-decay rate of $B^{12}$ is predicted correctly for a/K = 4.5, a value which is close to that favoured by other evidence. The calculated second-forbidden vector matrix element differs by 20% from the "experimental" value derived from a magnetic dipole transition rate in $C^{12}$.

539.17

### 4131 NEUTRON-INDUCED FISSION CROSS SECTION OF $Np^{237}$.

H.W.Schmitt and R.B.Murray.

Phys. Rev., Vol. 116, No. 6, 1575-7 (Dec. 15, 1959)

The neutron-induced fission cross-section of $Np^{237}$ was measur as a function of neutron energy in the range 0.9 to 8.0 MeV. Measurements above 1.7 MeV were made relative to the fission cross-sectio of $U^{238}$ using 2π-counting of fission fragments from thin fissile deposits placed back to back in a gridded ionization chamber. In the range 0.9 to 2.8 MeV the energy dependence of the $Np^{237}$ fission cross-section was determined relative to the $T(p,n)He^3$ yield, and the results were normalized to those of the comparison counting experiment in the overlapping energy range. Results show that the cross-section increases above threshold to a maximum value of 1.75 barns at ~2 MeV, decreases to 1.40 barns at ~5 MeV, and increases again to 2.14 barns at 8 MeV. Estimated uncertainty in the absolute magnitude of $\delta_f(Np)$ is ±7%.

539.17

4132

### EFFECTIVE CROSS-SECTION FOR FISSION OF Th$^{229}$.

B.M.Gokhberg, G.A.Otroshchenko and V.A.Shigin.
bkl. Akad. Nauk SSSR, Vol. 128, No. 5, 911-12 (Oct. 11, 1959).
Russian.

The cross-section for neutron-induced fission of Th$^{229}$ was easured with neutrons in the energy range 6 to 1200 keV. The utron source was the (p,n) reaction in tritium. J.A.Evans

539.17

4133

### MEASUREMENTS OF $\eta$ FOR U$^{233}$; U$^{235}$ AND Pu$^{239}$ WITH EPITHERMAL NEUTRONS.

L.E.Spivak, B.G.Erozolimsky, G.A.Dorofeev, Y.N.Lavrenchik, G.Kutikov and Y.P.Dobrynin.
nuclear Energy, Vol. 4, No. 1, 70-8 (Jan., 1957). English trans- tion of article in: Atomnaya Energiya, Vol. 1, No. 3, 13 (1956).

The behaviour of $\eta$ for U$^{233}$, U$^{235}$ and Pu$^{239}$ has been investigated the epithermal energy region. For U$^{233}$, $\eta$ remains constant up to nergies of the order of 100 eV. The value for Pu$^{239}$ falls by 12% in assing from a thermal spectrum to a spectrum bounded by 0.15 and 5 eV, but remains constant thereafter. $\eta$ for U$^{235}$ is the same for he thermal spectrum and that between 0.15 and 0.5 eV, but falls by 3% on passing to the spectrum from 8 to 130 eV.

539.17

4134

### MEASUREMENTS OF $\eta$ FOR U$^{233}$, U$^{235}$ AND Pu$^{239}$ WITH NEUTRONS IN THE ENERGY RANGE 30 TO 900 keV.

.E.Spivak, B.G.Erozolimsky, G.A.Dorofeev, V.N.Lavrenchik, E.Kutikov and Y.P.Dobrynin.
. nuclear Energy, Vol. 4, No. 1, 79-85 (Jan., 1957). English trans- ation of article in: Atomnaya Energiya, Vol. 1, No. 3, 21 (1956).

$\eta$ has been measured for U$^{233}$, U$^{235}$ and Pu$^{239}$ in the energy ange 30 to 900 keV. It is found to increase substantially with eutron energy in this region.

539.17

4135

### MEASUREMENTS OF $\eta$ FOR Pu$^{239}$ SPECIMENS CONTAINING SOME Pu$^{240}$, AND OF THE EFFECTIVE ESONANCE-ABSORPTION INTEGRAL FOR Pu$^{240}$.

.G.Erozolimsky, I.E.Kutikov, Y.P.Dobrynin, M.I.Pevzner, .S.Danelyan and S.S.Moskalev.
. nuclear Energy, Vol. 4, No. 1, 86-90 (Jan., 1957). English trans- ation of article in: Atomnaya Energiya, Vol. 1, No. 3, 27 (1956).

Measurements of $\eta$ have been made with the dE/E spectrum, ounded at the lower end by 0.15 eV and 0.4 eV as a result of using adolinium and cadmium filters respectively. The various Pu$^{239}$ pecimens contained 0, 1.6, 2.5, 6.5, and 16% of Pu$^{240}$. Results are lso given for effective resonance-absorption integral of Pu$^{240}$.

539.17

4136

### THE DISTRIBUTION OF FISSION-FRAGMENT KINETIC ENERGY IN TERNARY FISSION OF U$^{235}$ BY THERMAL NEUTRONS.

V.I.Mostovoi, T.A.Mostovaya, M.Sovinskii and Yu.S.Saltȳkov.
Atomnaya Energiya, Vol. 7, No. 4, 372-4 (1959). In Russian.

The fission fragments, and long-range $\alpha$-particles of energy > 7 MeV, were detected in a double ionization chamber and a coincidence circuit (background 10 to 30%). 17644 ternary fissions were recorded. After correction for the angle dependence of recording efficiency, the peaks of the heavy and light fragment energy distributions were found to be respectively 5.7 ± 0.5 and 8.1 ± 0.3 MeV less than in binary fission, and the mean excitation energy is calculated to be 5.87 MeV less. J.B.Sykes

539.17

4137

### THE MEAN NUMBER OF NEUTRONS EMITTED IN TERNARY FISSION OF U$^{235}$.

V.F.Apalin, Yu.P.Dobrȳnin, V.P.Zakharova, I.E.Kutikov and L.A.Mikaélyan.
Atomnaya Energiya, Vol. 7, No. 4, 375-6 (1959). In Russian.

The value measured with a double ionization chamber (detecting fission fragments, and long-range $\alpha$-particles of energy > 9 MeV) and a liquid-scintillator fission-neutron detector was 1.77 ± 0.09 (measured relative to the value for binary fission, taken as 2.45). About 5000 ternary fissions were recorded. When the $\alpha$-particle detection threshold was raised to 22 MeV, the result was 1.79 ± 0.13, so that the fission fragment excitation energy is independent of $\alpha$-particle energy. J.B.Sykes

539.17

4138

### RESONANCE FISSION WIDTHS OF U$^{235}$ FOR LEVELS FROM 6 eV TO 50 eV.

W.W.Havens, Jr., E.Melkonian, L.J.Rainwater and J.L.Rosen.
Phys. Rev., Vol. 116, No. 6, 1538-43 (Dec. 15, 1959).

The energy variation of the total and fission cross-sections of U$^{235}$ was measured with the Nevis synchrocyclotron neutron velocity spectrometer. Fission widths for most of the levels up to 50 eV were deduced from these measurements. The distribution of the 38 known fission widths shows that the number of channels available for the fission process is between one and four and is most probably two. If $\bar{\Gamma}_f$ is different for the two possible spin states of the compound nucleus, these cannot differ by more than an order of magnitude.

539.17

4139

### CALORIMETRIC DETERMINATION OF THE AVERAGE TOTAL KINETIC ENERGY OF FRAGMENTS FROM FISSION OF U$^{235}$ AND U$^{238}$ BY 14 MeV NEUTRONS.

P.C.Stevenson, H.G.Hicks, J.C.Armstrong, Jr and S.R.Gunn.
Phys. Rev., Vol. 117, No. 1, 186-91 (Jan. 1, 1960).

The fission yields of Mo$^{99}$ from 14 MeV neutron bombardments of U$^{235}$ and U$^{238}$ were found to be (5.01 ± 0.15)% and (5.86 ± 0.16)% respectively. The average total fragment kinetic energies released in fission of U$^{235}$ and U$^{238}$ were found to be 174 ± 4 and 175 ± 2 MeV, respectively.

539.17 : 537.56

### TRANSIENT TEMPERATURE VARIATIONS DURING THE SELF-HEATING OF A PLASMA BY THERMONUCLEAR REACTIONS.

See Abstr. 3759

## NUCLEAR POWER STUDIES

539.17

4140

### THE SWEDISH ZERO-POWER REACTOR R0.

R.Persson, C.E.Wikdahl, O.Landergård and K.Cavallin.
Tekn. T., Vol. 90, No. 2, 21-7 (Jan. 8, 1960). In Swedish.

This reactor is the second of Swedish design to be built, and is a development of the Zebra reactor. It is an experimental model for nuclear physical measurements. Its maximum permitted power is 50 W, but normal operating power is 1 W. It will be used primarily for the study of the natural uranium—heavy water system and for systematic investigations of neutron economy and reactor kinetics. It will be possible to compare various types of fuel element, the number and location of which can be varied within wide limits. The layout of the heavy water system and the vessel construction are described. G.N.J.Beck

539.17

4141

### THE HALDEN REACTOR.

N.Hidle.
Tekn. Ukeblad, Vol. 106, No. 41, 899-910 (Nov. 5, 1959).
In Norwegian.

The Halden reactor in S.E.Norway, the world's first boiling heavy water reactor began operation on 29 June, 1959. The reactor output is 10 MW, working pressure 40 kg/cm$^2$, temperature 250$^\circ$C. Natural U is used in the first charge. A simplified flow diagram of the reactor is shown. A survey is given of the reactor core characteristics, plant layout, reactor instrumentation, the international administration of the project, the pre-critical tests and the running up to full output. G.N.J.Beck

539.17

4142

### BOILING EXPERIMENTS IN CONNECTION WITH THE HALDEN BOILING WATER REACTOR CORE.

J.Asyee.
Tekn. Ukeblad, Vol. 106, No. 41, 911-19 (Nov. 5, 1959).

The natural circulation of the moderator-coolant in the b.w. reactor core under steady-state conditions was studied experimentally in Holland with the aid of a full-scale model of a unit-cell. To predict the reactor behaviour for other geometries, three basic properties were calculated from the results obtained: (1) the boiling length; (2) the relative or slip velocity of the phases; (3) the two-phase friction pressure drop. A relation is derived between instabilities and the negative slope of the circulation velocity v. power curve. A stability limit is defined and the influence of the geometry on this limit considered. G.N.J.Beck

539.17

### 4143 ANALOGUE COMPUTER STUDIES OF THE HALDEN BOILING WATER REACTOR.

N.Rydell, G.Ambrosini and H.Schmidl.
Tekn. Ukeblad, Vol. 106, No. 41, 920-6 (Nov. 5, 1959).

The dynamic behaviour (stability and transient response) of the power parameters of a reactor, such as neutron flux, temperatures, flows and pressures, largely determine the safety and operability of the reactor. The boiling-water reactor has a very complicated dynamic behaviour. To investigate this, equations for the neutron kinetics of the reactor were written down and a transfer function block diagram of the reactor drawn up. This transfer function model was set up on a PACE type 231 computer, almost the whole of the machine capacity being used. Two computer displays of operation hazards are shown. G.N.J.Beck

539.17

### 4144 THE DESIGN OF A PILE OSCILLATOR FOR THE FORD NUCLEAR REACTOR. J.Stone and W.Kerr.

Trans Amer. Inst. Elect. Engrs I, Vol. 77, 1003-6 (1959) = Commun. and Electronics, No. 40 (Jan., 1960).

The reactor reactivity is varied sinusoidally by the rotation, at constant angular velocity, of an eccentrically mounted circular disk, covered with cadmium foil, in and out of a fixed cadmium box. The rotating absorber is in the graphite reflector of the reactor. A circular parallel plate boron coated ionization chamber is used to detect the variation in neutron population; the signal obtained is automatically corrected for random variations in its amplitude. Operating procedures are briefly described for obtaining the reactor transfer function without feedback and the temperature feedback function, for investigating the stability of the reactor.
A.J.Salmon

539.17

### 4145 APPROXIMATE METHOD OF CALCULATING THE SURFACE LEAKAGE IN REACTORS. M.Ledinegg.

Atomkernenergie, Vol. 4, No. 9, 351-6 (Sept., 1959). In German.

An approximate method for calculating the neutron leakage is developed by applying simplified two-group diffusion equations, in terms of mean flux values, to a section of an infinite plane reactor and reflector. The limiting thickness of reflectors and the adaptation of the method to cylindrical and spherical reactors with reflectors are described. It is then shown that there is good agreement between the values for the neutron leakage obtained by this method and accurately calculated from two-group theory. D.H.Lord

539.17

### 4146 EXACT SOLUTION OF THE REACTOR KINETIC EQUATIONS FOR LINEAR, EXPONENTIAL, OR RECIPROCAL REACTIVITY DEPENDENCE ON TIME. H.B.Smets.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 45, No. 3, 256-71 (1959).

The general equations of reactor kinetics are integrated, by means of Laplacian integrals, for the three cases when the reactivity increases linearly, exponentially or reciprocally with time. In the first and second cases, their asymptotic solutions can be written, respectively, in terms of the parabolic cylinder function and of the function G of Meijer. When the delayed neutrons are represented by a single equivalent group, the solutions can be expressed in these cases in terms of the confluent hypergeometric functions.
D.H.Lord

539.17

### 4147 HEAVY ISOTOPE BUILDUP IN THE CORE OF A $U^{233}$ BREEDER. R.W.Stoughton and J.Halperin.

J. nuclear Energy, Vol. 4, No. 3, 279-92 (March, 1957).

The buildup of uranium isotopes with time in a $U^{233}$ breeder core was calculated for five different cases, the difference depending on the starting fuel and the isotopic composition of the continuously added make-up fuel. The total uranium concentration was found to approach slowly an equilibrium value of 2.6 to 3.5 times the starting value, depending on the composition of the make-up fuel. In all cases the net neutron losses per net neutron reproduced in the core go through a maximum of less than 1% at a flux time of about $3 \times 10^{21}$, go through a minimum of about −0.6% (i.e. a net gain) at about a flux time of $4 \times 10^{22}$, and approach equilibrium values of about 0.3% at flux times above $6 \times 10^{23}$.

539.17

### 4148 ON THE DEPENDENCE UPON ENERGY OF THE FISSION PRODUCT POISONING OF $U^{235}$.

U.L.Businaro, S.Gallone and D.Morgan.
J. nuclear Energy, Vol. 4, No. 3, 319-25 (March, 1957).

A calculation is made of the energy dependence of the average cross-section of the fission products of $U^{235}$. Two methods are used. One is based on the average over many resonances of cross-sections and uses low-energy data on average widths and spacings; the other applies the "continuum theory" formulae normalized on experimenta cross-sections at 1 MeV.

539.17

### 4149 LONG-TERM REACTIVITY CHANGES IN NUCLEAR REACTORS. B.L.Ioffe and L.B.Okun.

J. nuclear Energy, Vol. 4, No. 3, 371-86 (March, 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 4, 80 (1956

A method of calculating the fuel burnup in nuclear reactors is described which takes account of capture and multiplication of the neutrons in the course of slowing down. Calculations are performed which allow for the burnup of $U^{235}$ and the formation and burnup of $Np^{239}$, $Pu^{239}$, $Pu^{240}$, $Pu^{241}$ and fission products.

539.17

### 4150 APPROXIMATION OF THE SHORT TIME BEHAVIOUR OF REACTORS THROUGH LESS THAN SIX GROUPS OF DELAYED NEUTRONS. A.Kirchenmayer.

Nukleonik, Vol. 1, No. 7, 245-8 (Aug., 1959). In German.

Using an approximation for the decay curve of delayed neutrons, it is shown that the response to a sudden disturbance can be adequately calculated for times up to 10 seconds afterwards by using two groups of neutrons. J.Dutton

539.17

### 4151 THE RESPONSE OF A NUCLEAR POWER REACTOR TO A LINEAR REACTIVITY VARIATION. H.B.Smets.

Nukleonik, Vol. 1, No. 9, 351-7 (Dec., 1959).

Studied by topological methods, assuming temperature-dependen adiabatic, constant power removal and Newton's law of cooling. The stabilizing effect of the delayed neutrons and the properties of the solutions in the case of fast accidents are considered in detail. Comparison of theoretical approximate results (numerically solved) with experimental results obtained on the SPERT I and the KEWB reactors is very satisfactory.

539.17

### 4152 RESONANCE ESCAPE PROBABILITY IN SLAB LATTICES. N.Corngold.

J. nuclear Energy, Vol. 4, No. 3, 293-304 (March, 1957).

The slowing down of neutrons in a lattice consisting of alternate slabs of noncapturing moderator and nonmoderating fuel whose cross-sections vary arbitrarily with energy was examined. The Boltzmann equation is transformed to an integral equation into which appropriate boundary conditions are incorporated. Expansion of the flux functions in terms of orthogonal polynomials in space and angle coordinates yields an infinite set of coupled integral equations in energy. In the simplest approximation and for a hydrogen moderator these equations are easily integrated to give an expression for the resonance escape probability identical with the one recently derived — from quite different considerations — by Chernick (Geneva Conference paper A/Conf/8/P/603). It is shown that higher-order terms in these equations should contribute little to neutron absorption in those capture resonances which contribute most to the integrated capture probability. Thus, while the simplest approximation is not a good one for determining flux distributions, it will be quite good for determining resonance escape probabilities. Numerical results are given.

539.17 : 66

THE METALLURGY OF URANIUM BY THE NATIONAL COMMITTEE FOR NUCLEAR RESEARCH. See Abstr. 3392.

539.17 : 539.16

PNEUMATIC TUBES SPEED ACTIVATION ANALYSIS.
See Abstr. 4036

539.17

### 4153 THERMONUCLEAR REACTIONS.

G.P.Thomson.
Amer. J. Phys., Vol. 28, No. 3, 221-7 (March, 1960).

The possibility of extracting energy in a controlled manner from the nuclei of deuterium holds out the hope of a permanent solution of the problem of the supply of energy. It involves heating the gas to temperatures in the 100 million degree range. The outstanding difficulty is to prevent the heat escaping. Inevitable loss by radiation can be accepted. Loss by conduction must be greatly educed. This means using magnetic fields. Among the methods hat have been tried to contain a plasma, three are: the pinch disharge in which a large current is passed through the rarified deuerium in a torus; containment by magnetic mirrors in which the iamagnetic character of the plasma is used to exclude it from egions of high magnetic field; Spitzer's stellerator in which gas is ontained by re-entrant lines of force due to currents outside the essel which holds it. Difficulties arise in all cases; for the pinch ischarge and to some extent the stellerator, these are due to some f the many forms of instability which can affect plasma in magnetic ields; for the magnetic mirrors to the poor containment at relatvely low temperatures and to difficulties of injection. No method as yet been successful, but all these are very hopeful.

539.17

### 4154 THERMONUCLEAR RESEARCH IN THE UNITED STATES OF AMERICA. C.M.van Atta.

Proc. Instn. Elect. Engrs, Paper 3029 [Convention on Thermonuclear Processes] Vol. 106 A, Suppl. No. 2, 85-94, 100 (1959).

Outlines the principles of, and main results achieved in the U.S.A. with, the stellarator, the Magnetic Mirror machine, linear and toroidal pinch effect devices, the Astron device, and rotating plasma devices. R.S.Pease

539.17 : 537.56 : 621.3.039 : 621.387

### 4155 RAPID HEATING FOR CONTROLLED FUSION RESEARCH. R.A.Fitch.

Proc. Instn Elect. Engrs, Paper 3107 [Convention on Thermonuclear Processes] Vol. 106A, Suppl. No. 2, 177-81, 182-6 (1959).

The reasons for seeking a means of rapidly heating a plasma to thermonuclear temperatures are discussed, and it is suggested that shock compression by a rapidly increased magnetic field is a possible method. The problems of producing and maintaining such fields are considered, and it is concluded that capacitor discharge banks with the minimum inductance are required for both phases. The design of low-inductance condenser banks is discussed and it is suggested that the maximum rate of current rise attainable with presently available materials is about $10^{14}$ A/sec.

539.17

### 4156 REVIEW OF HIGH-TEMPERATURE ROTATING-PLASMA EXPERIMENTS. J.M.Wilcox.

Rev. mod. Phys., Vol. 31, No. 4, 1045-51 (Oct., 1959).

The basic equations for rotating plasmas are given and an effective dielectric constant for the plasma is derived. Four experimental approaches are reviewed: the Berkeley Homopolar device, the Los Alamos Ixion, and the Berkeley and Moscow ion-magnetron experiments. Details are given of the experimental evidence for plasma rotation, i.e. current and voltage monitors, magnetic induction monitors and spectroscopic Doppler measurements. A.H.Gabriel

539.17

### 4157 T - Nt DIAGRAM FOR FUSION RESEARCHES. M.Imoto, G.Tominaga and S.Fujii.

Prog. theor. Phys., Vol. 21, No. 6, 939-41 (June, 1959).

The energy balance in a thermonuclear reactor system is discussed in terms of the parameters temperature T and reduced time $\tau$ = Nt, where N = number density of ions and t = time. On a diagram of T versus $\tau$ for a given reacting system, contours enclose regions where power produced balances loss, a) over the whole period of operation, b) at each instance. It is pointed out that economical reactor operation is possible only in the region enclosed by both contours. Examples are given of the usefulness of the T - Nt diagram for particular reacting systems and fuel mixtures. R.E.Meads

539.17

### 4158 TRITIUM PRODUCTION AND CYCLING IN A FUSION REACTOR WITH LITHIUM BLANKET.

K.Hintermann and R.Wideröe.

Brown Boveri Rev., Vol. 45, No. 11-12, 588-95 (Nov.-Dec., 1958).

The proposal is made that the fusion reactor be surrounded by a lithium blanket, the tritium produced being used for the fusion process (tritium cycle). A mathematical treatment is given.

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## ATOMS

539.18 : 539.2

ELECTRON AFFINITIES OF THE HALOGENS. See Abstr. 2783

539.18 : 539.19

MEASUREMENT OF EXCITATION OF He BY ELECTRON IMPACT. See Abstr. 2755

539.18 : 539.12

IONIC REACTIONS OF NEGATIVE $\mu$-MESONS. See Abstr. 3981

539.18 : 539.12

SCHWINGER'S MESON AND THE $\mu$-MESIC ATOM. See Abstr. 3977

539.18

### 4159 SPECTRAL METHOD OF DETERMINING THE ISOTOPIC COMPOSITION OF LEAD. II.

A.N.Zaidel', A.G.Zhiglinskii and J.Čajko.

Czech. J. Phys., Vol. 8, No. 6, 665-84 (1958). In Russian, with summary ($1\frac{1}{2}$ pp.) in English.

The apparatus used was described in a previous paper (Abstr. 11617 of 1959). Several versions of the methods of isotopic spectral analysis of Pb with standards, without standards, and of mixed methods were developed. The intensities of components of hyperfine structure of the line Pb I 4058 A were measured. Methods without standards were shown to yield results deviating by up to 5-7% from those of mass-spectrometry, this deviation being reduced to 3-4% if the hollow cathode was cooled down to −183°C. If the content of the determined isotope is $\lesssim$10%, then the accuracy of the analysis conducted with standards is determined only by the accuracy of the standards themselves. F.Lachman

539.18

### 4160 ISOTOPE SEPARATION BY A HOT-WIRE THERMAL DIFFUSION COLUMN. S.C.Saxena and W.W.Watson.

Phys. of Fluids, Vol. 3, No. 1, 105-9 (Jan.-Feb., 1960).

The performance of a hot-wire thermal diffusion column is discussed. The role of spacers used for centering the hot wire has been investigated experimentally for a glass column of 9 mm i.d. cold wall, and hot wall 20 mil tungsten wire; the results suggest that the maximum separation is obtained when the spacers (20 mil nickel wire) are installed every 70 cm along the hot-wire. The separation falls when the spacers come either closer together or farther apart. An explanation of this optimum dependence of separation on spacer distance is advanced.

539.18 : 533.5

### 4161 ISOTOPE SEPARATION IN MOLECULAR PUMPS.

W.Fisher and A. Klemm.

Z. Naturforsch., Vol. 14a, No. 10, 851-860 (Oct., 1959). In German.

The compression and separation of gases in molecular pumps is calculated as a function of the throughput in the case of molecular and various flow. The theory is essentially confirmed by experiments on two commercial pumps. The observed separation factors are in accordance with a ten-fold multiplication of the simple process factor (S.P.F.). For example a separation factor of 1.5 is obtained for the neon isotopes. (S. P. F. = $\sqrt{22/20}$ ). H.C.Cole

539.18 : 537.534

ISOTOPIC ANALYSIS OF LITHIUM BY MASS SPECTROMETRY. See Abstr. 3812

539.18 : 539.17

XENON ISOTOPE ENRICHMENT BY THERMAL DIFFUSION. See Abstr. 4126

539.18 : 535.33

H.F.S. OF Lu, Gd AND Ho ISOTOPES. See Abstr. 3634

539.18

### 4162 TOTAL COLLISION CROSS SECTIONS FOR THE INTERACTION OF ATOMIC BEAMS OF ALKALI METALS WITH GASES. E.W.Rothe and R.B.Bernstein.

J. chem. Phys., Vol. 31, No. 6, 1619-27 (Dec., 1959).

Total collision cross-sections (Q) for the interaction of atomic beams of K and Cs with a number of molecules were measured with an apparatus of 30" angular resolution. Although absolute determinations of Q are difficult, relative values are readily obtained

($\pm 3\%$). Results are reported as the ratio ($Q^*$) of the cross-section for a given molecule to that of argon for the same beam atom. Seventy-seven molecules (of varied complexity and reactivity) were studied with K and 16 with Cs beams. $Q^*$ ranged from 0.29 to 2.8. The data were correlated using the Massey-Mohr theory, assuming an attractive intermolecular potential $V(r) = -C/r^6$. For this case, $Q = b(C/v_r)^{2/5}$, where $v_r$ is the relative velocity and b a known constant. C was estimated from standard formulae for the London dispersion and dipole-induced dipole forces, using known refraction and dipole moment data. The theoretical values of Q differ by a nearly constant factor from the experimental results; thus values of $Q^*$ are predicted with good accuracy. The deviation between $Q_{calc}^*$ and $Q_{obs}^*$ was $< \pm 3\%$ for 57% (and $< \pm 10\%$ for 87%) of the molecules. Most of the large deviations occurred for the light gases.

539.18

### 4163 EFFECTIVE CROSS-SECTIONS OF EXCITATION OF He $n^1P$-LEVELS BY SLOW ELECTRONS.

L.A.Vainshtein and G.G.Dolgov.

Optika i Spektrosk., Vol. 7, No. 1, 3-9 (July, 1959). In Russian.

Reports a numerical calculation (using an electronic computer) of the effective cross-sections of excitation of He $n^1P$-levels ($n = 2$, 3, 4) by slow electrons. The exchange interactions were neglected, since their inclusion would have meant a lot more computational work. A.Tybulewicz

539.18

### 4164 ON THE CHOICE OF ATOMIC ELECTRON WAVE-FUNCTIONS FOR SCATTERING PROBLEMS.

V.Veldre and R.Damburg.

Latv. PSR Zinat. Akad. Vestis, No. 7(144), 57-8 (1959). In Russian.

The calculation of electron scattering by atoms, using the method of integral equations, is discussed. The numerical results of some calculations for the 3s-state of lithium are quoted and used to show that the choice of Slater-type wave-functions for the atomic valence electron gives very poor results. R.F.Peierls

539.18

### 4165 ELASTIC SCATTERING OF SLOW ELECTRONS ON LITHIUM ATOMS.

V.Veldre, M.Gailitis, R.Damburg and P.Stepin'sh.

Latv. PSR Zinat. Akad. Vestis, No. 5(142), 73-6 (1959). In Russian.

Calculations were made using the integral equation method of Drukarev (Abstr. 464-5 of 1955; and Leningrad State University Dissertation - 1957), and results for singlet, triplet and total cross-section against the momentum of the incident electron given. The calculations ignore exchange interactions with the inner shell, magnetic interactions, and effects of inelastic scattering. Only S-waves were taken into account. J.A.Evans

539.18

### 4166 MEASUREMENT OF THE TOTAL, DIFFERENTIAL, AND EXCHANGE CROSS SECTIONS FOR THE SCATTERING OF LOW-ENERGY ELECTRONS BY POTASSIUM.

K.Rubin, J.Perel and B.Bederson.

Phys. Rev., Vol. 117, No. 1, 151-8 (Jan. 1, 1960).

An atom beam recoil technique was used to determine the total, Q, differential, $\sigma(\theta)$, and differential exchange, $\sigma_e(\theta)$, cross-sections for the scattering of low-energy electrons by potassium. The method consists of observing the angular distribution of atoms scattered from a potassium atom beam which has been cross-fired by an electron beam. Relative values of $\sigma(\theta)$ are then obtained by transforming to electron scattering angles. An inhomogeneous magnet and collimating channel are used as a velocity filter for the atom beam. Curves representing the variation of $\sigma(\theta)$ with $\theta$ between approximately 15° and 60° are presented for various electron energies between 0.6 and 9.0 eV. The magnet also serves to polarize the beam. Relative values of $\sigma_e(\theta)$ were determined by observing the amount of depolarization of the beam in the scattering region, using a second inhomogeneous magnet as an analyser. Over the observed range of angles, exchange accounts for approximately one third of the scattering. Bounds on the total exchange cross-section, $Q_e$, are also tabulated for energies between 0.5 and 4.0 eV. The bounds on $Q_e$ at 0.5 V are $0.8 \times 10^{-14}\ \mathrm{cm}^2 < Q_e < 1.6 \times 10^{-14}\ \mathrm{cm}^2$.

539.18 : 539.12

### 4167 LOW-ENERGY SCATTERING BY A COMPOUND SYSTEM : POSITRONS ON ATOMIC HYDROGEN.

L.Spruch and L.Rosenberg.

Phys. Rev., Vol. 117, No. 1, 143-51 (Jan. 1, 1960).

The formalism, developed by Kato, which gives upper and lower bounds on the phase shift for the scattering of a particle by a centre of force, has been generalized to apply to scattering by a compound system. Particularly simple and useful results are obtained for the case of zero energy scattering where no composite bound state exists. As a first example, because of its relative simplicity, the problem of low-energy positron scattering from atomic hydrogen, with zero total orbital angular momentum, is studied. It is shown that at zero energy the ordinary Kohn variational calculation, which ignores second order contributions, provides an upper bound on the scattering length, from which a bound on the cross-section is deduce For nonzero energies a bound on the phase shift may similarly be obtained, but for a fictitious problem with cutoff potentials. If the energy is sufficiently small (less than 3 eV, say) the error thus incurred is expected to be negligibly small. Numerical calculations performed at $k = 0$ and $ka_0 = 0.2$ lead to the result that at these energies the effects of polarization are large enough to cause the positrons to be on the whole attracted to the hydrogen atom.

539.18

### 4168 ELASTIC AND INELASTIC SCATTERING OF LOW-VELOCITY $D^+$ AND $D_2^+$ IN DEUTERIUM.

W.H.Cramer and A.B.Marcus.

J. chem. Phys., Vol. 32, No. 1, 186-8 (Jan., 1960).

Results are presented of the measurement in the energy range 4 to 400 eV of elastic and charge exchange cross-sections for $D^+$ and $D_2^+$ ions in $D_2$. Ordinary ionization was not observed. Charge exchange was detected above 65 eV for $D^+$ in $D_2$ and over the entire range of energies for $D_2^+$ in $D_2$. The present results are compared with measurements of collisions of hydrogen ions in $H_2$.

539.18 : 533.7

### CALCULATED TRANSPORT COEFFICIENTS FOR GASEOUS OXYGEN AND SULPHUR ATOMS. See Abstr. 3565

539.18

### 4169 ISOTOPE SHIFT FROM NON-UNIFORM NUCLEAR CHARGE DISTRIBUTIONS. A.S.Meligy.

Nuclear Phys., Vol. 14, No. 2, 248-55 (Dec. [2], 1959).

The isotope shift in atomic spectra is derived by solving Dirac's equations for an electron in the static field of a nuclear charge distribution of trapezoidal shape. The values of the parameters identifying this distribution are obtained from the analysis of the electron—nucleus scattering experiments. The magnitude of the derived isotope shift is found to be very nearly half the value previously predicted by a uniformly charged nucleus with radius $1.5 \times 10^{-13} A^{1/3}$ cm. Remarkable agreement is thus achieved between the isotope shift predicted by the present theory and the experimental results.

539.18

### 4170 IMPROVED Cu II STANDARD WAVELENGTHS IN THE VACUUM ULTRAVIOLET.

J.Reader, K.W.Meissner and K.L.Andrew.

J. Opt. Soc. Amer., Vol. 50, No. 3, 221-7 (March, 1960).

Interferometric wavelength measurements of sixty-one copper spark lines in the region 2884 to 1979A were carried out by means of a Fabry—Perot interferometer equipped with 4, 12, and 20 mm spacers. The light source used was a water-cooled hollow cathode Schüler tube operated principally with circulating helium but occasionally with circulating neon. The measurements were employed to establish the 4s and 5s even levels and 4p odd levels of Cu II. After fixing these low levels, their values were combined with the grating measurements of Carter and Shenstone to establish the values of certain higher odd and even levels. Use was then made of the Ritz combination principle to calculate precise wavelength values of approximately sixty copper lines in the region between 1663 and 984 A with estimated accuracies which varied from ±0.0003 to ±0.001 A.

539.18

### 4171 THE CONFIGURATIONS $(3d + 4s)^n$ IN THE SECOND SPECTRA OF THE IRON GROUP.

G.Racah and Y.Shadmi.

Bull. Res. Coun. Israel, Vol. 8F, No. 1, 15-46 (Sept., 1959).

The experimental levels of the low even configurations of the second spectra of the iron group are compared with the results of theoretical calculations. The significance of different approximations is discussed, and interpolation formulae are given for the interaction parameters.

539.18

### 4172 SELF-ABSORPTION IN AN ELECTRODELESS DISCHARGE IN HYDROGEN AND HELIUM.

J.A.Harrison.

Proc. Phys. Soc., Vol. 73, Pt 6, 841-8 (June, 1959).

Describes a simple and direct way of measuring self-absorption in a 24 Mc/s discharge. The results obtained with hydrogen and helium at pressures between $12\mu$ and 1.6 mm of Hg are used to determine absorption coefficients and excited level populations. Under the conditions described, self-absorption of $H_\alpha$ and $H_\beta$ must be taken into account when measuring line intensities.

539.18

### 4173 POLARIZATION OF RADIATION OF HELIUM ATOMS EXCITED BY ELECTRON COLLISIONS.

G.G.Dolgov.

Optika i Spektrosk. Vol. 6, No. 6, 717-22 (June, 1959). In Russian.

An electron-optical system was used to produce an electron beam of $5\mu A/mm^2$ density, monochromatic to within 0.5-0.7 eV. Helium pressure in the system was $2 \times 10^{-4}$ mm Hg and optical emission was observed at right-angles to the electron beam. Polarization was defined as

$$\Pi = (J_\parallel - J_\perp)/(J_\parallel + J_\perp),$$

where $J_\parallel$ is the component of light polarized parallel to the electron beam and $J_\perp$ is the component polarized at right-angles to the electron beam. The apparatus used included special devices for recording $\Pi$ directly. The results obtained are explained on a semi-classical model of excitation (S-P transitions) of helium atoms by electrons. A.Tybulewicz

539.18

### 4174 THE INFLUENCES WHICH AFFECT THE LINE INTENSITIES IN FLAME SPECTRA.

N.S.Tskhai and S.L.Mandel'shtam.

Optika i Spektrosk., Vol. 7, No. 2, 141-51 (Aug., 1959). In Russian.

Changes in the intensities of the lines in the flame spectra of sodium and strontium were observed when the form of the compound used to introduce the element was altered (e.g. NaCl, $Na_2CO_3$ and $Na_2SO_4$ for sodium and $SrCl_2$, $Sr(NO_3)_2$ for strontium) and when compounds of other elements (e.g. $MgCl_2$, $CaCl_2$, $SrCl_2$, $BaCl_2$) were introduced into the flame. Solutions of the compounds employed were injected into the flame by means of an atomizer. It was found that the changes were due to two factors: (1) a change in the free sodium or strontium atomic density in the flame due to a change in the rate of supply of the solution, and (2) a change in the conditions of excitation due to a change in the flame temperature. A.Tybulewicz

539.18

### 4175 ANOMALIES IN THE INTENSITIES OF THE HYPERFINE-STRUCTURE COMPONENTS OF THALLIUM RESONANCE LINES.

Yu.I.Turkin.

Optika i Spektrosk., Vol. 7, No. 1, 10-13 (July, 1959). In Russian.

Reports a study of reversal of h.f.s. components of two thallium resonance lines at 2767.8 and 3775.7 A seen against a continuous background provided by a high-pressure krypton lamp. The upper (F = 1) sublevel of the ground state $6^2P_{\frac{1}{2}}$ of helium was found to be more densely populated than could be expected under equilibrium conditions. This higher population density is due to the longer lifetime of excited atoms in the F = 1 sublevel, compared with the F = 0 (lower) sublevel. A.Tybulewicz

539.18

### 4176 ISOTOPIC SHIFT IN THE URANIUM SPECTRUM.

L.A.Korostȳleva and G.A.Striganova.

Optika i Spektrosk., Vol. 7, No. 2, 137-40 (Aug., 1959). In Russian.

The authors measured the isotopic shift on 46 uranium lines with two-component isotopic structure in the region 4000-6000 A. A Fabry—Perot interferometer crossed with a three-prism spectrograph and a discharge tube with a hollow-aluminium cathode were used. The samples employed had 30% $U^{235}$ and 70% $U^{238}$. A.Tybulewicz

539.18 : 533.7

KINETIC GAS THEORY APPLIED TO EMISSION SPECTRA. See Abstr. 3559

539.18 : 539.16

CHARGE SPECTRUM OF $Br^{79}$ ATOMS PRODUCED BY $Kr^{79}$ DECAY. See Abstr. 4052

539.18

### 4177 THE PHOTOELECTRIC EFFECT AT HIGH ENERGIES.

T.Erber.

Ann. Phys. (New York), Vol. 8, No. 3, 435-72 (Nov., 1959).

The total cross-section for the photo-ejection of a 1s electron is calculated in the limit of high energies. Although initial and final states are both represented by the exact Dirac wave-functions, it is possible to carry out all operations, except the last, in closed form. The final integral is evaluated by approximate analytical techniques as well as by machine calculation. The results are not in quantitative agreement with previous work. Symmetries of the high-energy matrix elements permit an immediate extension of the discussion to bound-pair production (annihilation) and capture-bremsstrahlung.

## MOLECULES

539.19

### 4178 GENERALIZED PERTURBATION METHOD EMPLOYING NONORTHOGONAL FUNCTIONS.

S.M.Blinder.

J. chem. Phys., Vol. 32, No. 1, 111-15 (Jan., 1960).

A method is developed for solving second-order perturbation problems without explicit knowledge of the higher molecular states. This method involves, in principle, a transformation of basis from the set of orthonormalized eigenfunctions of the unperturbed molecular Hamiltonian arbitrary set of functions not, in general, either normalized or mutually orthogonal, but of such symmetry that perturbation matrix elements connecting them to the ground state do not vanish. In the new basis is chosen expediently, convergence to second-order eigenvalues may be attained with a small number of functions. The method is related to the conventional perturbation and variational approaches. As an illustration, the perturbed harmonic oscillator is treated.

539.19

### 4179 TRAPPED FREE RADICAL CONCENTRATIONS.

C.E.Hecht.

J. chem. Phys., Vol. 32, No. 2, 365-70 (Feb., 1960).

Average concentrations of trapped free radicals condensed from a gaseous mixture are calculated on the basis of a statistical model that assumes these concentrations to be those obtaining in the solid for which the free radicals and diluents are distributed in such a way that the entropy of the system is a maximum. This entropy is calculated in an independent pair, Bethe approximation. All kinetic and energetic considerations are neglected. The results are given as a function of diluent concentration and of the number of nearest neighbours in the solid. When condensed from a completely dissociated gas without diluents the free radical fraction ranges from 0.12 for a simple cubic lattice to 0.08 for a face-centred cubic lattice.

539.19

### 4180 POTENTIAL FUNCTION OF BORIC ACID.

C.W.F.T.Pistorius.

J. chem. Phys., Vol. 31, No. 6, 1454-7 (Dec., 1959).

A normal coordinate treatment was carried out for the planar $X(YZ)_3$ molecule (symmetry point group $C_{3h}$) by means of Wilson's F-G matrix method (Abstr. 184 of 1940; 438 of 1941), using the most general harmonic force field. Ten of the most important force constants of boric acid were determined from existing infrared and Raman data.

539.19

### 4181 ION BINDING BY SPHERICAL POLYELECTROLYTE MOLECULES.

F.T.Wall, J.A.Cote and S.M.Rucker.

J. chem. Phys., Vol. 31, No. 6, 1640-2 (Dec., 1959).

For previous work, see Abstr. 4018 (1957). Additional numerical solutions have been obtained for the Poisson—Boltzmann equation applied to spherical polyelectrolyte molecules. The results deal with cases involving smaller charge densities and smaller polyion radii than heretofore. Calculations have also been made for a model of polyelectrolyte immersed in a sea of multi-multivalent electrolyte. In addition to computing the electrical potential in and about the polyion, the extent of counter-ion binding has also been calculated. It is found that the binding of counter-ions is determined principally by the charge of the ion of sign opposite that of the polyelectrolyte and that it depends very little on the magnitude of the charge of the ion with sign like that of the central sphere.

539.19

### 4182 KRYPTON—XENON BANDS.

W.Friedl.

Z. Naturforsch., Vol. 14a, No. 9,848 (Sept.,1959). In German.

High-voltage discharge through a Kr—Xe mixture gives bands in the visible attributed to a Kr—Xe molecule. A—Xe mixtures behave similarly. G.F.Lothian

539.19

### 4183 COMPARISON OF EXACT AND APPROXIMATE ENERGY LEVELS FOR A HINDERED ROTATOR.

A.A.Evett.

J. chem. Phys., Vol. 31, No. 5, 1419-20 (Nov., 1959).

The solutions to an approximate problem used in Abstr. 8685 (1959) are not close enough to the exact solutions obtained for the lowest rotational levels (Abstr. 12741 of 1959) for the former to be useful. J.Hawgood

539.19

### 4184 MOLECULAR PARTITION FUNCTIONS IN TERMS OF LOCAL PROPERTIES.

D.R.Herschbach, H.S.Johnston and D.Rapp.

J. chem. Phys., Vol. 31, No. 6, 1652-61 (Dec., 1959).

The classical partition function for a polyatomic molecule is obtained in a form which has, for each atom, a factor that corresponds to free translational motion of the atom in an effective volume defined by the average vibrational amplitudes of the atom and the geometrical configuration of the neighboring atoms. A method is given for calculating the appropriate volume elements for any choice of internal coordinates. The treatment includes harmonic vibrations, internal rotations, and "reaction coordinates". Quantum mechanical corrections introduce additional factors which shrink the volume elements for high-frequency vibrations. Since the principal factors in this form of the partition function are determined by local properties largely characteristic of the bonds in the vicinity of each atom, many of these factors remain practically constant and can be omitted in calculations which compare the reactants in a chemical reaction with the products or with the "activated complex".

539.19

### 4185 VALENCE BOND CALCULATION OF THE BARRIER TO INTERNAL ROTATION IN MOLECULES.

G.M.Harris and F.E.Harris.

J. chem. Phys., Vol. 31, No. 6, 1450-3 (Dec., 1959).

An approximate calculation of the barrier to internal rotation in ethane was made using a set of covalent valence bond structures involving only s and p orbitals. The calculated result is sufficiently great that it does not appear that other effects are needed to explain the barrier height.

539.19

### 4186 DEVELOPMENT OF A METHOD OF DETERMINING THE RELAXATION TIME OF THE VIBRATIONAL STATE OF MOLECULES USING A SPECTROPHONE. I. DERIVATION OF A MORE ACCURATE DEPENDENCE BETWEEN THE MEASURED PHASE-SHIFT AND THE RELAXATION TIME.

P.V.Slobodskaya and E.S.Gasilevich.

Optika i Spektrosk., Vol. 7, No. 1, 97-104 (July, 1959). In Russian.

Describes apparatus which employs a Veingerov spectrophone (an optico-acoustic receiver) in measurement of the relaxation time of a particular type of vibration. The phase-shift $\psi$ due to the gas in the optico-acoustic receiver was found to be related to the vibrational relaxation time $\tau$ by $\tan\psi = \omega\tau$, where $\omega$ is the frequency of interruption of light signals in the receiver. To obtain the value of $\psi$ allowance must be made for the phase-shifts due to thermal inertia of the gas, acoustical properties of a microphone used in the receiver, inertia of a photocell used to record the light signals etc. The apparatus was used to measure the relaxation time of $CO_2$, using its 2.7 and 4.3 $\mu$ absorption on bands. The relationship given by the above formula was confirmed for the 4.3 $\mu$ band; the 2.7 $\mu$ band results were affected by the presence of water vapour, which also absorbs at 2.7 $\mu$. A.Tybulewicz

539.19

### 4187 POTENTIAL ENERGY CONSTANTS, ROTATIONAL DISTORTION CONSTANTS, AND THERMODYNAMIC PROPERTIES FOR $NH_3$, $ND_3$; $PH_3$, $PD_3$; $AsH_3$, AND $AsD_3$.

S.Sundaram, F.Suszek and F.F.Cleveland.

J. chem. Phys., Vol. 32, No. 1, 251-4 (Jan., 1960).

Normal coordinate analyses are made for ammonia ($NH_3$), phosphine ($PH_3$), and arsine ($AsH_3$) by the Wilson FG matrix method. Using the data on anharmonicities, and the corresponding completely deuterated molecules, the constants of the most general quadratic potential energy function have been obtained for all these molecules. Based on the technique of Kivelson and Wilson, the rotational distortion constants of all the 6 molecules have been determined and compared with the results obtained from previous rotational spectra data. The molar thermodynamic properties, heat content, free energy, entropy, and heat capacity, also have been calculated for temperatures from 100 to 1000°K for the ideal gaseous state at 1 atm pressure and for a rigid-rotor, harmonic-oscillator approximation.

539.19

### 4188 VIBRATIONAL ASSIGNMENT AND POTENTIAL FIELD OF IRON PENTACARBONYL.

C.W.F.T.Pistorius and P.C.Haarhoff.

J. chem. Phys., Vol. 31, No. 6, 1439-43 (Dec., 1959).

The fundamental frequencies were assigned using recent vibrational data. The results show that iron pentacarbonyl possesses a trigonal bipyramidal structure. Valency force constants were evaluated for a force field consisting only of the diagonal F-matrix elements.

539.19

### 4189 VIBRATIONAL DISTRIBUTION IN LATE NITROGEN AFTERGLOWS. R.A.Young and K.C.Clark.

J. chem. Phys., Vol. 32, No. 2, 604-6 (Feb., 1960).

The late portion of long afterglows in nitrogen at a pressure of 1 mm Hg was investigated spectroscopically, revealing that during 140 sec of decay no change occurs in the characteristic relative vibrational distribution of the $N_2$ ($B\,^3\Pi \rightarrow A\,^3\Sigma$) 1st positive bands. A common excitation mechanism for all levels is required; it cannot depend upon known metastable particles formed in the initial discharge or generated during the decay.

539.19

### 4190 EXCITATION OF THE AURORAL GREEN LINE IN NITROGEN AFTERGLOWS. R.A.Young and K.C.Clark.

J. chem. Phys., Vol. 32, No. 2, 607-11 (Feb., 1960).

Production of the auroral green line of OI($^1D$—$^1S$, 5577 A) was observed during long (30 sec) afterglows in a static system containing nitrogen and small amounts of oxygen. Relative to the intensities of the $N_2$ 1st positive bands, the measured intensities of 5577 A and the NO$\beta$ bands increase with time. The long period of observation definitely eliminates the initial discharge as a possible source of the metastable oxygen atoms, and their chemical excitation in the afterglow volume is established. A probable process consistent with observations is that involving collision of N atoms with vibrationally excited NO molecules. This mechanism is discussed as a possible source of 5577 A in the airglow.

539.19

### 4191 ROTATIONAL TRANSFER IN THE FLUORESCENCE SPECTRUM OF OH($^2\Sigma^+$). T.Carrington.

J. chem. Phys., Vol. 31, No. 5, 1418-19 (Nov., 1959).

Irradiation of the gas above a $C_2H_2$—$O_2$ flame with the Bi resonance line 3067.7 A line excites OH to the K = 11 rotational state of OH($^2\Sigma^+$). The relative populations of the initial rotational state and of other states populated by collisions with it are obtained from the intensities of fluorescence from the states involved. The number of molecules leaving K = 11 by rotational transfer is found to be about twice the number leaving by loss of electronic energy. G.F.Lothian

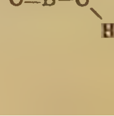
539.19

### 4192 INFRARED EMISSION SPECTRUM OF GASEOUS $HBO_2$.

D.White, D.E.Mann, P.N.Walsh and A.Sommer.

J. chem. Phys., Vol. 32, No. 2, 488-92 (Feb., 1960).

The infrared emission spectrum of the vapour phase of the $B_2O_3(l)$-$H_2O(g)$ system was studied at elevated temperatures over the region 700-400 cm$^{-1}$. Characteristic bands were found near 3680, 2030, and 1420 cm$^{-1}$, and approximate $B^{10}$—$B^{11}$ and H—D isotope shifts measured. It is shown that these bands arise from the molecule $HBO_2$. The intensity of the 2030 cm$^{-1}$ band was studied as a function of both temperature and water pressure. The intensity versus the temperature measurements lead to a heat of formation, $\Delta H_0^0$, of $-135.0 \pm 3$ kcal/mole for $HBO_2(g)$. The spectroscopic data, considered in the light of the analysis of the $B_2O_3(g)$ infrared spectrum, are compatible with the structure



$$O{=}B{-}O\diagdown H$$

which the OBO group is linear and the H is off-axis. The force constants are found to resemble those determined for $B_2O_3(g)$. Complete vibrational assignments are given for $HBO_2(g)$ and its trimer $(HBO_2)_3(g)$, a species which has recently been shown to exist in this system. Thermal functions have been computed for both molecules over a wide temperature range.

539.19

### 4193 INFRARED EMISSION SPECTRA OF GASEOUS $B_2O_3$ AND $B_2O_2$.

.White, D.E.Mann, P.N.Walsh and A.Sommer.

. chem. Phys., Vol. 32, No. 2, 481-7 (Feb., 1960).

The infrared emission spectra of gaseous $B_2O_3$ and $B_2O_2$ in the temperature range 1400-1800$^0$ K were studied in the region 00-4000 $cm^{-1}$. Distinct bands were found for natural $B_2O_3$ at 2040, 302, and 742 $cm^{-1}$, and the $B^{10}-B^{11}$ isotope shifts measured. From the isotope shift data and other considerations the $B_2O_3$ molecule has been assigned a V structure having $C_{2v}$ symmetry. A force constant analysis has been made and a frequency assignment is given from which thermal functions have been computed. The calculated force constants are consistent with the high stability of the molecule. Only one emission band of gaseous $B_2O_2$, at 1890 $cm^{-1}$, was observed. A linear $D_{\infty h}$ structure was assumed and a frequency assignment and thermal functions estimated.

539.19

### 4194 FAR INFRARED SPECTRA OF SOME SYMMETRIC TOP MOLECULES.

D.W.Robinson and D.A.McQuarrie.

J. chem. Phys., Vol. 32, No. 2, 556-9 (Feb., 1960).

Pure rotational spectra out to 30 $cm^{-1}$ are presented of the gaseous molecules $CH_3CN$, $CH_3CCH$, $HCF_3$ and $(CH_3)_3N$. These spectra are interpreted in view of the rotational constants previously determined from microwave data. The heretofore undetermined value of $D_J$ for $CH_3CN$ was estimated to be $1.45 \times 10^{-7}$ $cm^{-1}$, the value of $D_{JK}$ for $(CH_3)_3N$ is shown to be positive, and the intensity distribution in the high-J subbands of the oblate top, $HCF_3$, is estimated to have its centre at K = 17.

539.19

### 4195 ABSORPTION SPECTRUM OF FORMAMIDE VAPOR IN THE 2700-3700 $cm^{-1}$ REGION.

J.C.Evans.

J. chem. Phys., Vol. 31, No. 5, 1435-6 (Nov., 1959).

The bands observed are as expected for the correct planar molecular structure and confirm other recent studies. (Abstr. 126 of 1958). G.I.W.Llewelyn

539.19

### 4196 THE INFRARED FUNDAMENTAL BAND OF LIQUID AND SOLID HYDROGEN.

H.P.Gush, W.F.J.Hare, E.J.Allin and H.L.Welsh.

Canad. J. Phys., Vol. 38, No. 2, 176-93 (Feb., 1960).

The infrared fundamental band of liquid and solid hydrogen was investigated over a range of para-concentrations from 25% to 100% with a prism spectrometer and, in part, with a grating spectrometer at a resolution of ~0.2 $cm^{-1}$. The spectrum of the solid shows (a) comparatively sharp Q,S(0), and S(1) lines due to quadrupolar interaction, (b) broad bands interpreted as combination tones of the molecular frequencies with the lattice frequencies (phonon spectra), and (c) weak double transitions of the type $S_1(0)+S_0(0)$. At high resolution the quadrupolar S(0) and S(1) groups show weak single transitions, $S_1(0)$ and $S_1(1)$, and much stronger double transitions of the type $Q_1(J)+S_0(J), J = 0,1$. In solid parahydrogen the lines become very sharp and the double transition, $Q_1(0)+S_0(0)$, shows a complex structure; the observations are in good agreement with the theory of the rotational and vibrational levels of solid parahydrogen by Van Kranendonk. The quadrupolar Q branch shows a structure which is interpreted as double transitions of the type $Q \pm \delta_i$, where the $\delta_i$ are the small changes in energy due to the orientational transitions of two ortho-molecules. The phonon spectra show a maximum at the Debye temperature of the solid, and, at higher resolution, a structure indicative of the various branches of the lattice frequencies. A long extension of the phonon spectrum towards high frequencies is probably due to multiple phonon creation. Double transitions, for which the cancellation principle in induced absorption does not apply, account for at least 98% of the intensity of the spectrum of the solid.

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### 4197 THEORY OF THE INFRARED AND RAMAN SPECTRA OF SOLID PARAHYDROGEN.

J. Van Kranendonk.

Canad. J. Phys., Vol. 38, No.2, 240-61 (Feb., 1960).

The theory of the rotational and vibrational energy bands in solid hydrogen, developed previously, is applied to the interpretation of the infrared and Raman spectra of solid parahydrogen. A comparison of the theory with the experimental results yields information about the nature of the rotational and vibrational motions of the molecules in the solid, and about the anisotropic intermolecular forces. A calculation of the intensity of the infrared rotational and vibrational lines is given, which is based on the induction mechanisms introduced previously to explain the induced absorption in gaseous hydrogen. Satisfactory agreement with the experimental values is obtained. The importance of the interaction between other than nearest neighboring molecules, and of the interference effects affecting the single transitions, is pointed out. A frequency analysis is given of the infrared and Raman rotational and vibrational lines in the solid, and a consistent theory of the shifts and splittings of the various lines is obtained. Empirical values of the rotational and vibrational coupling constants are derived and compared with the theoretical values.

539.19

### 4198 WAVELENGTH CALIBRATIONS IN INFRARED. III. $\nu_2$ OF HCN AT 14 MICRONS.

K.Narahari Rao, W.W.Brim and J.M.Hoffman.

J. Opt. Soc. Amer., Vol. 50, No. 3, 228-31 (March, 1960).

In Pts I and II See Abstr. 3278-9 (1959). The rotational structure of the $\nu_2$ band of the HCN molecule at 14 $\mu$ was measured using neon lines in the visible as wave-number markers and the 1-0 vibration-rotation band lines of the CO molecule as secondary standards. There is good agreement between these measurements and the values calculated by Rank et al. from their observations of a number of near-infrared vibration-rotation bands of the HCN molecule. Details of the determination of frequencies of infrared lines are given to assist in an appreciation of the probelms involved and the approach pursued in their solution.

539.19

### 4199 VIBRATIONAL—ROTATIONAL STRUCTURE IN THE SPECTRA OF SOME SIMPLE MOLECULES IN SOLUTION.

J.Lascombe, P.van Huong and M.L.Josien.

Bull. Soc. Chim. France, 1959, 7-8. 1175-80 (July-Aug.). In French.

The infrared spectra of HF, HCl, HBr, HI, CO, NO, and $CH_4$ have been measured in the gaseous state and in solution in $CCl_4$, $CS_2$ and toluene. Results are given graphically and in tabular form and possible interpretations discussed and partly verified by determination of temperature effects. G.I.W.Llewelyn

539.19

### 4200 ROTATIONAL SPECTRUM OF $H_2O$ VAPOUR AND ABSORPTION BY MOIST AIR IN THE WAVELENGTH REGION FROM 40 TO 2500 MICRONS.

N.G.Yaroslavskii and A.E.Stanevich.

Optika i Spektrosk., Vol. 6, No. 6, 799-801 (June, 1959). In Russian.

Reports measurements of the infrared spectrum of water vapour in the region 1400-2500 $\mu$ (7.15-4.0 $cm^{-1}$) and absorption by atmospheric air in the region from 40 to 2500 $\mu$.

A.Tybulewicz

539.19

### 4201 VIBRATION-ROTATION BANDS OF AMMONIA. IV. THE STRETCHING FUNDAMENTALS AND ASSOCIATED BANDS NEAR 3 $\mu$.

W.S.Benedict, E.K.Plyler and E.D.Tidwell.

J. chem. Phys., Vol. 32, No. 1, 32-44 (Jan., 1960).

For Pt III, see Abstr. 1822 (1959). High resolution spectra of $NH_3$, yielding 1800 lines between 3060-3580 $cm^{-1}$, are presented. Analysis of the $\nu_3$ fundamental is complete through J' = 9 and presents no unexpected features. Resolution of the K substructure in the $\nu_1$ fundamental shows that several perturbations are present. The most important of these, involving a Fermi resonance with the parallel component of $2\nu_4$, and a Coriolis resonance with its perpendicular component, are clarified. Lines in both components of $2\nu_4$ are identified through J' = 6, and a strong Coriolis interactions between the $l = 0$ and $l = 2$ states is observed and discussed.

539.19

### 4202 VIBRATIONAL SPECTRA OF $OsF_6$ AND $PtF_6$.

B.Weinstock, H.H.Claassen and J.G.Malm.

J. chem. Phys., Vol. 32, No. 1, 181-5 (Jan., 1960).

Infrared absorption spectra of gaseous $OsF_6$ and $PtF_6$ from 6-50 $\mu$ and the Raman spectrum of liquid $OsF_6$ are reported. These are interpreted in terms of the octahedral point group $O_h$, and the six fundamental frequencies are determined. Their values and symmetry species are for $OsF_6$ 733 ($a_{1g}$), 632 ($e_g$), 720 ($f_{1u}$), 268 ($f_{1u}$), 252 ($f_{2g}$), and 230 ($f_{2u}$); for $PtF_6$ 655 ($a_{1g}$), 601 ($e_g$), 705 ($f_{1u}$), 273 ($f_{1u}$), 242 ($f_{2g}$), and 211 ($f_{2u}$). Thermodynamic functions, including electronic contributions, are calculated for the ideal gaseous state of both compounds. A comparison of the details of the vibrational spectra of eleven hexafluorides reveals certain characteristic features for $OsF_6$ and $ReF_6$. Since only these two molecules have appropriately degenerate electronic ground states these differences are interpreted as evidence of a Jahn–Teller effect.

539.19

### 4203 A THEORY OF INTENSITIES OF THE INFRARED SPECTRA OF SULPHUR DIOXIDE, AMMONIA AND PHOSPHINE MOLECULES.

L.M.Sverdlov.

Optika i Spektrosk., Vol. 7, No. 2, 152-63 (Aug., 1959). In Russian.

The author derives by theoretical calculation the intensities of the infrared spectra and the electro-optical parameters (the dipole moments and the derivatives of the dipole moments with respect to the bond length) of $SO_2$, $NH_3$ and $PH_3$. The calculation was carried out in the first approximation of the valence-optical scheme using natural vibrational coordinates: changes in the bond lengths and magnitudes of the angles. The calculated dipole moments of sulphur dioxide ammonia and phosphine were $\mu_{SO_2} = 1.5872$, $\mu_{NH_3} = -1.3057$ and $\mu_{PH_3} = -0.3389$ D.

A.Tybulewicz

539.19

### 4204 INFRARED SPECTRA OF METAL-CHELATE COMPOUNDS. I. A NORMAL COORDINATE TREATMENT ON BIS-(ACETYLACETONATO)-Cu(II).

K.Nakamoto and A.E.Martell.

J. chem. Phys., Vol. 32, No. 2, 589-97 (Feb., 1960).

A normal coordinate treatment on the chelate ring of bis-(acetylacetonato)-Cu(II) gives calculated frequencies in good agreement with the observed ones in the 1700 and 350 $cm^{-1}$ range obtained with NaCl, KBr, and CsBr optics. In order to assign the observed bands and to see the coupling between various vibrational modes, the L matrices and the potential energy distribution, $Lii^2Fi$ were calculated for all the in-plane vibrations. The results reveal that (1) the band at 1580 $cm^{-1}$ previously assigned to asym. CO stretching is asym. CC stretching, (2) the bands at 684 and 654 $cm^{-1}$ formerly suggested to be metal-oxygen stretching modes are metal-oxygen stretching vibrations coupled with ring deformation and $CCH_3$ bending modes, respectively, and (3) a new band found at 455 $cm^{-1}$ is the sym. Cu–O stretching mode. By comparing the force constants of the Cu–O stretching vibration with those of metal-nitrogen and metal-carbon bonds of other compounds, it is suggested that the Cu–O bond in this compound has double bond character.

539.19

### 4205 INFRARED SPECTRUM AND THE FUNDAMENTAL FREQUENCY ASSIGNMENTS FOR TRIFLUOROMETHANETHIOL ($CF_3SH$).

R.E.Dininny and E.L.Pace.

J. chem. Phys., Vol. 31, No. 6, 1630-2 (Dec., 1959).

Infrared spectral results for gaseous trifluoromethanethiol ($CF_3SH$) in the 3-22 $\mu$ range are presented. By comparison with methyl mercaptan ($CH_3SH$) and the isoelectronic molecule trifluoromethyl chloride ($CF_3Cl$), the following assignment, (in $cm^{-1}$ units), of the fundamentals is made: $\nu_1 = 1136$; $\nu_2 = 1179, 1167$; $\nu_3 = 463$; $\nu_4 = 521$ (splitting not observed); $\nu_5 = 763$; $\nu_6 = 342$ (splitting not observed); $\nu_7 = 2618$; and $\nu_9 = 540$. The torsional mode $\nu_8$ was not observed.

539.19

### 4206 TEMPERATURE DEPENDENCE OF RAMAN INTENSITIES.

G.W.Chantry.

J. chem. Phys., Vol. 32, No. 1, 222-3 (Jan., 1960).

The temperature dependence of the intensity of the Raman lines of a polyatomic molecule has been investigated. It is shown that, when account is taken of all possible "hot" band transitions as well as fundamental transitions, the temperature dependence of each band is the same as that found for the single band of a diatomic molecule. Degenerate vibrations are also considered and likewise shown to have the same temperature dependence.

539.19

### 4207 SUBSTITUTED METHANES. XXIX. VIBRATIONAL SPECTRA, POTENTIAL CONSTANTS, AND CALCULATED THERMODYNAMIC PROPERTIES FOR DIBROMOCHLOROFLUOROMETHANE AND BROMODICHLOROFLUOROMETHANE.

R.L.Gilbert, E.A.Piotrowski, J.M.Dowling and F.F.Cleveland.

J. chem. Phys., Vol. 31, No. 6, 1633-6 (Dec., 1959).

For Pt XXVIII, see Abstr. 730 of 1959. Raman displacements, semiquantitative relative intensities, and quantitative depolarization factors for the Raman lines of the liquid, and wave numbers and estimated relative intensities for the infrared bands of the gas and liquid in the region 400 to 3000 cycles/cm, were obtained for $CBr_2ClF$ and $CBrCl_2F$. Assignments of the observed bands were made and reasonable sets of potential energy constants were determined by use of the Wilson FG matrix method and the procedure of Gold, Dowling, and Meister. Finally, the thermodynamic properties — heat content, free energy, entropy, and heat capacity — were calculated from the spectral and structural data for 12 temperatures from 100 to 1000°K.

539.19

### 4208 RAMAN INTENSITIES OF THE $A_1$ LINES OF OXYANIONS.

G.W.Chantry and R.A.Plane.

J. chem. Phys., Vol. 32, No. 2, 319-21 (Feb., 1960).

The trace of the derived polarizability tensor was measured on an absolute scale for the ions $CO_3^=$, $NO_3^-$, $PO_4^{-3}$, $SO_4^{-2}$, and $ClO_4^-$ in aqueous solution. From these and the known normal coordinate matrix elements, the values of the derivative with respect to bond length have been calculated. Results are interpreted in terms of bond order, and indicate appreciable $\pi$ bonding in the ions $NO_3^-$, $SO_4^{-2}$, and $ClO_4^-$. In these cases, as opposed to hydrocarbons, a $\pi$ electron makes a larger contribution to the derived bond polarizability than does a $\sigma$ electron.

539.19

### 4209 ON THE RELATIONSHIP BETWEEN THE VIBRATIONAL STRUCTURE OF ELECTRONIC BAND SPECTRA AND THE RESONANCE RAMAN EFFECT.

J.Behringer and J.Brandmüller.

Ann. Phys. (Leipzig), Folge 7, Vol. 4, No. 1-5, 234-42 (1959). In German.

A relation exists between the Raman and the electronic band spectrum in terms of frequency and intensity, which is particularly marked in the case of the resonance Raman effect. Experimental observations are given for a number of organic compounds. For the study of these relations the most suitable substances are those showing well-defined absorption and fluorescent spectra.

R.C.Seymour

539.19

### 4210 ON THE MICROWAVE SPECTRUM AND ELECTRIC DIPOLE MOMENT OF FLUOROBENZENE.

D.G.De Kowalewski, P.Kökeritz and H.Selén.

J. chem. Phys., Vol. 31, No. 5, 1438 (Nov., 1959).

Five microwave absorption frequencies not previously reported are tabulated for the J = 2 → 3 rotational transitions. A value of 1.66 D is deduced for the dipole moment of fluorobenzene.

G.I.W.Llewelyn

539.19

### 4211 MICROWAVE SPECTRUM AND INTERNAL ROTATION OF ETHYL CYANIDE.

V.W.Laurie.

J. chem. Phys., Vol. 31, No. 6, 1500-5 (Dec., 1959).

The microwave spectrum of ethyl cyanide was studied in the region 17-36 k Mc/s. Both parallel and perpendicular transitions were assigned. Rotational constants (Mc/s) for the ground vibrational state are $a_0 = 27\,663.30$, $b_0 = 4714.14$, $c_0 = 4235.14$, $D_J = 0.0035$, $D_{JK} = -0.0496$. From Stark effects the dipole moment is calculated to be $\mu_a = 3.78$ D, $\mu_b = 1.38$ D, $\mu = 4.02$ D. Hyperfine splittings lead to a value of $-3.3$ Mc/s for the quadrupole coupling of the $N^{14}$ nucleus along the a axis. Rotational transitions of molecules in several excited vibrational states were also measured. A Coriolis interaction between the torsional mode and the in-plane CCN bend was found and is discussed. Splittings of transitions of molecules in the first excited torsional state show that the barrier hindering internal rotation of the methyl group is 3.05 kcal/mole.

539.19

### 4212 INTERNAL ROTATION IN MOLECULES WITH TWO INTERNAL ROTORS: MICROWAVE SPECTRUM OF ACETONE.

J.D.Swalen and C.C.Costain.

J. chem. Phys., Vol. 31, No. 6, 1562-74 (Dec., 1959).

The theory of internal rotation in molecules is extended to the case of two internal symmetric rotors attached to a molecule with $C_{2v}$ symmetry. The calculation of the internal rotational energy levels and of the interaction with the over-all rotational energy levels discussed both for the high barrier and the low barrier approxi- ation. The symmetry of the Hamiltonian for a molecule with the etone structure is considered and the selection rules and relative tensities of the various fine structure components are derived. e microwave spectra of acetone and of completely deuterated etone were measured and assigned. From the rotational constants, e molecular structure was partially determined. The most probable lues of the structural parameters are $r_0$(C=O) = 1.215 A (assumed), (C−C) = 1.515 ± 0.005 A, $r_0$(C−H) = 1.086 ± 0.010 A, ∠CCC = 6° 14' ± 1°, and ∠HCC = 110° 16' ± 1°. The angle between the es of the methyl groups is approximately 3° larger than ∠CCC. e dipole moment was determined to be 2.90 D by a measurement the Stark effect on the microwave transitions. Each of the tational transitions is split into a number of components by the ternal rotation. From an analysis of these patterns the barrier ight to internal rotation is found to be 274 cm$^{-1}$ for $(CH_3)_2CO$ and 8 cm$^{-1}$ for $(CD_3)_2CO$. The difference in the two calculated barrier ights and the errors in the method are discussed.

539.19

### 4213 BEAM MASER SPECTROSCOPY ON HDO.

P.Thaddeus and J.Loubser.

uovo Cimento, Vol. 13, No. 5, 1060-4 (Sept. 1, 1959).

A beam maser of the type originally used by Gordon,Zeiger and ownes (Abstr. 9061 of 1954) to investigate the magnetic hyperfine ructure of the $NH_3$ inversion lines has been used to resolve the yperfine structure of the $2_{20} - 2_{21}$ rotational transition in HDO which es at 10 278.245 Mc/s. The quadrupole satellites reported by osener (Abstr. 4880 of 1957) have been fully resolved, and sub- antial effects due to magnetic interactions confirmed.

J.M.Baker

539.19

### 4214 THE ELECTRONIC ABSORPTION SPECTRA OF $NH_2$ AND $ND_2$.

K.Dressler and D.A.Ramsay.

hil. Trans A, Vol. 251, 553-604 (Oct. 8, 1959).

Absorption spectra in the region 3900-8300 A have been recor- ed with a 21 ft concave grating spectrograph, for the radicals $^{14}H_2$, $N^{15}H_2$ and $N^{14}D_2$ produced by flash photolysis of $N^{14}H_3$, $N^{15}H_3$ nd $N^{14}D_3$. The isotope shifts in $N^{14}H_2$−$N^{15}H_2$ show that the molecule s linear in the excited state. Molecular constants have been deri- ed from the data e.g. bond lengths and bond angles for $NH_2$ and $D_2$ in the ground state agree and are 1.024±0.005 A and 103°20'±30' espectively. The short bond length of 0.97$_5$ A in the linear confi- uration is discussed. The complex vibronic structure observed in e excited state is explained in terms of the Renner effect. The xperimental data agree with a theoretical treatment by Pople and onguet Higgins (Abstr. 13741 of 1959).

R.C.Seymour

539.19

### 4215 GROUND STATE OF THE $C_2$ MOLECULE.

E.A.Ballik and D.A.Ramsay.

J. chem. Phys., Vol. 31, No. 4, 1128 (Oct., 1959).

Experimental evidence is presented which proves that the ground state of the $C_2$ molecule in the gas phase is the $^1\Sigma^+_g$ state and not the $\Pi_u$ state as hitherto supposed.

W.J.Orville-Thomas

539.19

### 4216 ELECTRONIC STRUCTURE OF $CH_2$ AND $CH_3$.

A.Padgett and M.Krauss.

J. chem. Phys., Vol. 32, No. 1, 189-95 (Jan., 1960).

The self-consistent field molecular orbital method is applied to the calculation of the ground states of the $CH_2$ and $CH_3$ molecules. All electrons are explicitly considered but the three- and four- centre electron repulsion integrals were approximated. Results are reported for the dissociation energies, excitation energies, ioniza- tion potentials, and the hyperfine splitting constants for the Fermi or "contact" term. The values reported for the dissociation energies are in poor agreement with experiment but some qualitative insight into the bonding of these molecules is obtained by an electron popu- lation analysis.

539.19

### 4217 ISOTROPIC PROTON HYPERFINE INTERACTION IN THE METHYL RADICAL.

J.Higuchi and S.Aono.

J. chem. Phys., Vol. 32, No. 1, 52-5 (Jan., 1960).

The isotropic hyperfine interactions of radicals or ions have been discussed from the viewpoint of the self-consistent field (SCF) molecular orbital theory. In these phenomena, the most important electron configurations concerned are those arising due to the one electron excitations from the double occupied orbital to the vacant orbital together with the lowest energy configuration. The proton hyperfine splitting of the methyl radical was calculated nonempiric- ally by using the SCF-LCAO-MOs in adopting the first order perturbation. The agreement with the observed value is quite good when using MOs that include the 3s AO of carbon atom, while it is not so satisfactory in the case of the MOs without the 3s AO, because of the improvement of the form of the totally symmetric antibonding vacant orbital which gives the main contribution to the phenomena.

539.19

### 4218 ELECTRON SPIN RESONANCE STUDIES OF SEMI-QUINONES AND THE C−F BOND.

D.H.Anderson, P.J.Frank and H.S.Gutowsky.

J. chem. Phys., Vol. 32, No. 1, 196-204 (Jan., 1960).

The electron spin resonance spectrum was observed for a solution of tetrafluoro p-benzosemiquinone and a value, $a_F$ = 4.14 ± 0.08 gauss, obtained for the fluorine hyperfine splitting. It is concluded that this splitting is caused by the $\sigma-\pi$ configuration interaction proposed for protons attached to an aromatic free radical. The results show that the fluorine orbital in the C−F bond contains about 5% s character. The relationship between the hyperfine splitting constants and the contact contribution to the electron coupling of nuclear spins is commented upon. The electron spin density $\rho_C$ at a carbon atom in an aromatic free radical is related to $a_F$, for a fluorine bonded to the carbon, by the approximate relation $a_F \cong 40\rho_C$. Data are presented which can be explained by assuming the semi- quinone free radicals produced by air oxidation by hydroquinones in alcoholic KOH dimerize or otherwise react in concentrated solution to give radicals with oxygen linkages, while dibenzosemiquinone radicals are produced from quinones under reducing conditions. An X-band spectrometer was used; a brief description is given of it and of an electronic sweep unit for the electromagnet.

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### 4219 ELECTRON SPIN RESONANCE STUDIES OF THE POTASSIUM SALT OF m-DINITROBENZENE NEGATIVE ION.

R.L.Ward.

J. chem. Phys., Vol. 32, No. 2, 410-16 (Feb., 1960).

A detailed analysis of the electron spin resonance spectrum for the potassium salt of m-dinitrobenzene negative ion in DME (1,2-dimethoxyethane) is presented. Isotopic substitution was performed in various positions in the molecule. m-Dinitrobenzene negative ion exhibits only one nitrogen hyperfine interaction of 9.0 gauss, and possesses proton hyperfine interactions of 4.6 gauss for the number 2, 4, and 6 protons and 1.2 gauss for the number 5 proton. The hyperfine spectrum is different for each of the alkali metals. Li, Na, K, Rb, and Cs, but still remains only one nitrogen hyperfine interaction. An enriched $Li^6$ metal salt of m-dinitrobenzene indi- cates no alkali metal hyperfine interaction.

539.19

### 4220 DERIVATION OF A FORMULA OF TOWNES—DAILEY TYPE FOR THE CALCULATION OF THE ELECTRIC FIELD GRADIENT AT THE NUCLEUS, INCLUDING OVERLAP.

H.Lefèvre.

C.R. Acad. Sci. (Paris), Vol. 249, No. 10, 947-9 (Sept. 7, 1959).

In French.

The effect of bonding on the nuclear quadrupole coupling con- stant can be expressed in the Townes—Dailey form by using a Mulliken approximation for the integrals.

J.Hawgood

539.19

### 4221 INEQUALITY OF THE COUPLING CONSTANTS OF THE HYDRAZYL NITROGENS IN DPPH.

R.M.Deal and W.S.Koski.

J. chem. Phys., Vol. 31, No. 4, 1138-9 (Oct., 1959).

E.S.R. at X and K-band was performed on solutions of DPPH in benzene at room temperature and the line shapes compared with careful reconstructions to determine whether the hyperfine coupling constants of the two nitrogen nuclei are equal. A ratio of these constants of 0.82 ± 0.01 is given assuming that the individual hyper- fine lines have a Gaussian shape. The arguments for expecting a Gaussian shape are given.

J.M.Baker

539.19

### 4222 EFFECTS OF "RING CURRENTS" ON THE N.M.R. SPECTRA OF PORPHYRINS.

E.D.Becker and R.B.Bradley.

J. chem. Phys., Vol. 31, No. 5, 1413-14 (Nov., 1959).

The unusually large chemical shifts observed are attributed to the effect of precession of $\pi$-electrons about closed paths in the porphyrin rings. E.F.W.Seymour

539.19

### 4223 N.M.R. SPECTRA OF NORMAL AND DEUTERATED METHYLACETYLENES.

W.R.Vaughan and R.C.Taylor.

J. chem. Phys., Vol. 31, No. 5, 1425-6 (Nov., 1959).

The proton resonance of $CH_3CCH$ consists of a single multiplet rather than a multiplet from each of the $CH_3$ and CH groups. This was found, by separate observations of the multiplets from $CH_3CCD$ and $CD_3CCH$, to be due to accidental equality of the two chemical shifts. E.F.W.Seymour

539.19

### 4224 C$^{13}$ SPLITTINGS IN PROTON MAGNETIC RESONANCE SPECTRA. II. BONDING IN SUBSTITUTED METHANES.

N.Muller and D.E.Pritchard.

J. chem. Phys., Vol. 31, No. 6, 1471-6 (Dec., 1959).

For Pt I, see Abstr. 12490 (1959). Indirect spin—spin couplings were measured between protons and C$^{13}$ nuelci in a variety of substituted methanes. As found earlier for hydrocarbons, the coupling constants, $J_{C-H}$, appear to be linearly related both to the percent s character of the carbon atomic orbital participating in the C—H bond and to the bond length. On the basis of the large variations of the $J_{C-H}$ values and of the C—H bond lengths in these compounds it is concluded that the state of hybridization of the carbon atom cannot be reliably inferred from the observed, essentially tetrahedral valence angles. This means that the bond must in many cases be considered as somewhat bent. The authors investigated the dependence of the C—H bond hybridization in compounds of type $CH_3X$ upon the properties of the substituent groups. The results can be correlated on the assumption that the effective electronegativity and the size of the atom directly attached to the methyl carbon primarily determine the hybridization.

539.19

### 4225 DEPENDENCE OF C$^{13}$—PROTON SPIN COUPLING CONSTANTS ON s CHARACTER OF THE BOND.

J.N.Shoolery.

J. chem. Phys., Vol. 31, No. 5, 1427-8 (Nov., 1959).

The observed coupling constants for singly, doubly and triply bonded carbon atoms are directly proportional to the s character of the C—H bond, showing that the coupling is predominantly due to the electron—nucleus contact interaction. E.F.W.Seymour

539.19

### 4226 SIGNS OF THE PROTON SPIN—SPIN COUPLING CONSTANTS IN PURE ETHYL ALCOHOL.

P.T.Narasimhan and M.T.Rogers.

J. chem. Phys., Vol. 31, No. 5, 1428-9 (Nov., 1959).

Better agreement is obtained between the experimental n.m.r. spectrum, and that calculated by direct solution of the secular equation for the nuclear system, if the $CH_3$—$CH_2$ and $CH_2$—OH coupling constants are assumed to have the same, rather than opposite, signs. E.F.W.Seymour

539.19

### 4227 PROTON MAGNETIC RESONANCE SPECTRUM OF PROPANE.

D.R.Whitman, L.Onsager, M.Saunders and H.E.Dubb.

J. chem. Phys., Vol. 32, No. 1, 67-71 (Jan., 1960).

Exact proton magnetic resonance eigenspectra of the spin Hamiltonian are calculated for a system containing one group of six identical protons and one group of two identical protons. The method of calculation considers each group of identical protons as a composite "particle" with fixed total spin, and does not require determination of the explicit form of the zero-order eigenfunctions. The calculated spectra are compared with experimental high-resolution spectra of propane at both 40 and 60 Mc/s. The values of $\rho$, the ratio of the spin coupling constant to the chemical shift, are found to be 0.415 and 0.277, respectively, at the two frequencies. The frequency-independent spin coupling constant is 7.26 c/s.

539.19

### 4228 RELATIVE SIGNS OF THE MERCURY—PROTON SPIN—SPIN COUPLING CONSTANTS IN MERCURY DIETHYL.

P.T.Narasimhan and M.T.Rogers.

J. chem. Phys., Vol. 31, No. 5, 1430 (Nov., 1959).

An analysis of the proton magnetic resonance spectrum shows that the coupling constants of Hg$^{199}$ and the protons of the $CH_2$ and $CH_3$ groups are of opposite signs. E.F.W.Seymou

539.1

### 4229 CHEMICAL SHIFTS IN THE NUCLEAR MAGNETIC RESONANCE OF Co$^{59}$ AND THE LIGAND FIELD THEORY.

S.S.Dharmatti and C.R.Kanekar.

J. chem. Phys., Vol. 31, No. 5, 1436-7 (Nov., 1959).

The chemical shifts observed in fifteen compounds agree with those calculated from ligand field theory using spectroscopic values of excited molecular energy levels, to within the 20% estimated accuracy of the calculated values. E.F.W.Seymou

539.1

### 4230 FIELD GRADIENTS AT THE DEUTERON IN MOLECUL

R.Bersohn.

J. chem. Phys., Vol. 32, No. 1, 85-8 (Jan., 1960).

A survey of the observed quadrupole coupling constants of the deuteron is presented. It is concluded on the basis of calculation that the field gradients at hydrogen nuclei will be positive in almost all molecules. The simple wave-functions greatly underestimate the field gradients of the bonding electrons. A good part, but not al of the discrepancy, previously noted by White, can be removed with the use of a contracted charge distribution and ionic character. The wave-function of Ellison and Shull gives a very bad description of th field gradients at the deuterons in $D_2O$ but the experimental data indicate the direction for future improvement. The field gradients at deuterons remain attractive quantities for characterizing the charge density in bonds involving hydrogen atoms.

539.1

### 4231 MOLECULAR ORBITAL STUDIES OF DIATOMIC MOLECULES. I. METHOD OF COMPUTATION FOR SINGLE CONFIGURATIONS OF HETERONUCLEAR SYSTEMS.

F.E.Harris.

J. chem. Phys., Vol. 32, No. 1, 3-18 (Jan., 1960).

Describes a method of molecular orbital calculation for heteronuclear diatomic molecules, in the approximation of a single spatial configuration which is a product of one-electron functions. The method is applicable to systems in which the one-electron orbitals are not required to be either orthogonal or filled in pairs. A practical procedure is presented for treating permutational symmetry and spin for an arbitrary spatial wave-function, and using this procedure all the spin configurations associated with the chosen spatial wave-function are considered simultaneously. The wave-functions used are parametric expressions in spheroidal coordinates, and include the usual Slater orbitals as special cases. All necessary integrals are evaluated in a manner suitable for machine computation. A computer programme to implement this method of calculation has been prepared, and with it an approximate energy level for a 6-electron molecule can be obtained in about 8 min. Provision was made to programme the computer to vary the parameters of the wave-functions so as to find automatically the wave-function of minimum energy of the parametric form chosen. Only a part of the calculation need be repeated after varying parameters, and the optimum retention of computed data for re-use is discussed.

539.19

### 4232 EVALUATION OF ONE-CENTER ELECTRON REPULSION INTEGRALS BETWEEN CERTAIN S-TYPE ATOMIC ORBITALS.

W.D.Jones and F.L.Brooks, Jr.

J. chem. Phys., Vol. 32, No. 1, 124-6 (Jan., 1960).

A general formula is derived for one centre s-type electron repulsion integrals for the set of basic atomic orbitals which involve the complete set of associated Laguerre functions of order $(2l + 1)$ and degree $(n + l + 1)$ with a single orbital exponent.

539.19

### 4233 SPIN DENSITIES IN ODD ALTERNANT HYDROCARBON RADICALS.

R.Lefebvre, H.H.Dearman and H.M.McConnell.

J. chem. Phys., Vol. 32, No. 1, 176-81 (Jan., 1960).

The spin densities at the starred and unstarred carbon atoms of odd alternant hydrocarbon radicals have been calculated using the method of alternant molecular orbitals introduced by Löwdin. The spin densities at unstarred positions are shown to be negative in sign and to depend upon the electron correlation parameter $\theta$. Observed spin densities on one carbon atom can be used to estimate $\theta$ and to calculate spin densities on other carbon atoms. Illustrative calculations for the cases of triphenylmethyl and perinaphthenyl are described.

539.19

### 4234 NATURE OF THE FREE ELECTRON MODEL. THE SIMPLE CASE OF THE SYMMETRIC POLYMETHINES.

.Kuhn, W.Huber, G.Handschig, H.Martin, F.Schäfer and F.Bär.
chem. Phys., Vol. 32, No. 2, 467-9 (Feb., 1960).

In the case of the polymethines

$$H_2C{=}CH(CH{=}CH)_{j-1}\overset{\oplus}{C}H_2$$

nd

$$H_2C{=}CH(CH{=}CH)_{j-1}\overset{\ominus}{C}H_2$$

e wave-functions and energy levels of the $\pi$ electrons given by the ne-dimensional free electron model are compared with those ven by more elaborate methods in which the $\pi$ electrons are reated as electrons in a one- or two-dimensional core potential obtained from nuclear charge and shielding considerations. The esults of the three treatments are in good agreement, and thus the eliability of the simple free electron model is justified.

539.19

### 4235 NATURE OF THE FREE ELECTRON MODEL. THE CASE OF THE POLYENES AND POLYACETYLENES.

.Bär, W.Huber, G.Handschig, H.Martin and H.Kuhn.
chem. Phys., Vol. 32, No.2, 470-5 (Feb., 1960).

The wave-functions and energy levels of the polyenes and polycetylenes found on the basis of the simple sine curve potential odel are compared with those given by more refined methods in hich the $\pi$ electrons are treated as electrons in a one-, two-, or ree-dimensional core potential obtained from nuclear charge and ielding considerations. The results of the four treatments are in ood agreement, and by considering the electron density distribution long the chain each treatment leads to the same conclusion, that ach single bond and each double (or triple) bond in a long-chain olyene (or polyacetylene) must have, respectively, the same length s the single bond and double (or triple) bond in butadiene (or acetylene). The values of the absorption maxima given by the ur models are in good agreement with the experimental values.

539.19

### 4236 MICROWAVE SPECTRUM, STRUCTURE, DIPOLE MOMENT, AND NUCLEAR QUADRUPOLE EFFECTS IN INYL CHLORIDE.

D.Kivelson, E.B.Wilson, Jr. and D.R.Lide, Jr.
. chem. Phys., Vol. 32, No. 1, 205-9 (Jan., 1960).

The microwave spectra of nine isotopic species of vinyl chloride were measured and analysed, yielding moments of inertia from which a molecular structure was calculated. The bond lengths found are (in A) C=C $1.33_2$, C—Cl $1.72_6$, average C—H 1.08. The bond angles are $C_2C_1Cl$ $122^0$, $C_2C_1H_1$ $124^0$, $C_1C_2H_3$ (cis to Cl) $121^0$, $C_1C_2H_2$ trans to C.) $120^0$. Planarity was assumed. The chlorine nuclear quadrupole hyperfine lines were reexamined. From the data for several isotopic species it was shown that the C—Cl bond direction is within five degrees of a principal axis of the field gradient tensor. The lack of cylindrical symmetry of the field gradient about the C—Cl bond was confirmed. This is evidence that the observed shortening of the C—Cl bond is at least in part due to conjugation with the C=C double bond and not solely to hybridization effects. The component of dipole moment along the a inertial axis was found to be 1.42 ± 0.02 D.

539.19

### 4237 DIPOLE MOMENT OF HD.

S.M.Blinder.
J. chem. Phys., Vol. 32, No. 1, 105-10 (Jan., 1960).

The HD molecule has a small permanent electric dipole as a consequence of the asymmetry of nuclear vibration. The complete molecular Hamiltonian contains a term which is not invariant to inversion of electronic coordinates through the molecular centre. This gives rise to an axial asymmetry of electronic charge. Treating the term as a perturbation, it is found that the ${}^1\Sigma_g{}^+$ electronic ground state is perturbed only by states of ${}^1\Sigma_u{}^+$ symmetry. Assuming that only the lowest such state (the B state) contributes, an upper bound on the permanent moment is established. For the ground vibrational state this is computed to be $8.89 \times 10^{\ 4}$ Debye unit, directed in the sense $H^+D^-$.

539.19

### 4238 DIPOLE MOMENT FUNCTION FOR HD.

S.M.Blinder.
J. chem. Phys., Vol. 32, No. 2, 582-7 (Feb., 1960).

The wave-function method of Trischka and Salwen for computing dipole moment functions is applied to the HD molecule. From data on relative intensities of the weak rotation-vibration transitions, several possible dipole functions are constructed. The one having a maximum coincident with the vibrational potential minimum is believed to be the most reasonable.

539.19

### 4239 MICROWAVE SPECTRUM AND MOLECULAR STRUCTURE OF FORMAMIDE.

C.C.Costain and J.M.Dowling.
J. chem. Phys., Vol. 32, No. 1, 158-65 (Jan., 1960).

The microwave spectra of ten isotopic species of formamide ($H_2N{-}CHO$) were investigated. Type a and type b transitions were identified and measured for all ten species. The inertial defect is found to decrease whenever a heavier isotope is substituted for any atom in the $NH_2$ group, and in fact is negative for four of the species studied. It is concluded that the molecule is nonplanar with the $H_2N{-}C$ group forming a shallow pyramid. The structural parameters deduced from the rotational constants are: r(N—H′, where H′ is trans to the aldehyde hydrogen)= 1.014 ± 0.005 A, r(N—H″, where H″ is cis to the aldehyde hydrogen = 1.002 ± 0.005 A, r(N—C) = 1.376 ± 0.010 A, r(C—H) = 1.102 ± 0.010 A, r(C=O) = $1.19_3$ ± 0.020 A, ∠H′NH″ = $118^0 53'$ ± 40′, ∠H″NC = $120^0 37'$ ± 40′, ∠H′NC = $117^0 9'$ ± 40′, ∠NCO = $123^0 48'$ ± 40′, ∠NCH = $113^0 14'$ ± ±40′ and ∠OCH = $122^0 58'$ ± 40′. The dihedral angles between the H′NC plane and the NCO plane, and between the H″NC plane and the NCH plane, are $7^0 \pm 5^0$, and $12^0 \pm 5^0$, respectively. In all the spectra investigated each line was accompanied by a vibrational satellite line of anomalously high intensity. Measurements of relative intensities were carried out for $H_2N^{14}{-}CHO$, cis- and trans-$HDN^{14}{-}CHO$, and $D_2N^{14}{-}CHO$. The energy levels (above the zero point) deduced from these measurements show a very large isotope shift, and are interpreted as being due to the first excited state of the $NH_2$ wagging frequency. A pyramidal model for formamide will have two equilibrium configurations separated by a potential barrier. With a Manning type potential, a barrier of 370 ± 50 $cm^{-1}$, hindering the "inversion-wagging" type of motion, is determined. The equilibrium value of the normal coordinate calculated from the Manning potential is found to be in good agreement with that found in the structure determination.

539.19

### 4240 POTENTIAL ENERGY CONSTANTS, ROTATIONAL DISTORTION CONSTANTS, AND THERMODYNAMIC PROPERTIES OF $B^{11}H_3CO$, $B^{11}D_3CO$, $B^{10}H_3CO$, AND $B^{10}D_3CO$.

S.Sundaram and F.F.Cleveland.
J. chem. Phys., Vol. 32, No. 1, 166-8 (Jan., 1960).

Potential energy constants are obtained for the $BH_3CO$ molecule by use of the Wilson FG matrix method. The derivatives of the moments of inertia tensor components, with respect to the symmetry coordinates, of an axially symmetric $ZX_3YW$ molecule of $C_{3V}$ symmetry are evaluated. With these derivatives and the elements of the potential energy matrices, the rotational distortion constants for $B^{11}H_3CO$, $B^{11}D_3CO$, $B^{10}H_3CO$, and $B^{10}D_3CO$ are calculated. The calculated values are in good agreement with the values obtained in the microwave experiments by Gordy et al. The heat content, free energy, entropy, and heat capacity have been calculated for the four molecules for the ideal gaseous state at 1 atm pressure, with a rigid-rotor harmonic-oscillator approximation.

539.19

### 4241 ELECTRON DIFFRACTION STUDY OF THE STRUCTURE OF TRIMETHYLPHOSPHINE.

L.S.Bartell and L.O.Brockway.
J. chem. Phys., Vol. 32, No. 2, 512-15 (Feb., 1960).

The structural parameters of gaseous trimethylphosphine, including standard errors, were found to be as follows: centre of gravity bond distances were $r_{CP} = 1.845_5 \pm 0.003$ A, and $r_{CH} = 1.091 \pm 0.006$ A; angles were $\sphericalangle C{-}P{-}C = 98.6 \pm 0.3^0$, and $\sphericalangle P{-}C{-}H = 110.7 \pm 0.5^0$; root-mean-square amplitudes of vibration were $l_{CP} = 0.054 \pm 0.003$ A, $l_{CH} = 0.073 \pm 0.006$ A, $l_{P--H} = 0.110 \pm 0.006$ A, and $l_{C--C} = 0.084 \pm 0.005$ A. The barriers probably 1.5 kcal/mole or higher. A brief structural comparison with halogen derivatives and hydrides is presented.

539.19

### 4242 FREE VOLUME THEORY FOR SQUARE-WELL POTENTIALS.

B.J.Alder.
J. chem. Phys., Vol. 31, No. 6, 1666-74 (Dec., 1959).

The thermodynamic functions are tabulated for molecules interacting with a square-well potential over a wide region of temperature and density by a straightforward application of the free volume theory.

539.19

### 4243 CONDITIONS IMPOSED BY GROSS PROPERTIES ON THE INTERMOLECULAR POTENTIAL.

H.L.Frisch and E.Helfand.

J. chem. Phys., Vol. 32, No. 1, 269-70 (Jan., 1960).

The conditions for, and implications of, the existence of a maximum in the second virial coefficient as a function of temperature are investigated. Brief comment is made on the use of the inversion of Laplace transforms, with respect to the reciprocal temperature, to obtain information about intermolecular potentials and cross-sections from second virial coefficients and dilute gas transport coefficients.

539.19

### 4244 SHORT-RANGE INTERACTION BETWEEN A HYDROGEN MOLECULE AND A HYDROGEN ATOM. II.

W.J.Jameson,Jr. and H.Aroeste.

J. chem. Phys., Vol. 32, No. 2, 374-7 (Feb., 1960).

For Pt I, see Abstr.6210 (1959). Computations of the interaction between a hydrogen atom and a hydrogen molecule, where one of the three atoms is in a two-quantum electronic state, have been made using a modified Heitler—London procedure. The calculated interaction energies of the system including a degenerate state for which the magnetic quantum number is m = 0 are about 5 eV lower than the previous Heitler—London results in which no excited states were considered. The results are compared with experimentally determined energies, and a possible explanation of the discrepancy between theoretical and experimental values is presented. Calculations are also presented for cases where m = 1.

539.19

### 4245 INTERACTIONS BETWEEN GROUND STATE OXYGEN ATOMS AND MOLECULES: O—O AND $O_2$—$O_2$.

J.T.Vanderslice, E.A.Mason and W.G.Maisch.

J. chem. Phys., Vol. 32, No. 2, 515-24 (Feb., 1960).

Potential energy curves for O—O interactions corresponding to the X $^3\Sigma_g^-$, $^1\Delta_g$, $^1\Sigma_g^+$, $^3\Delta_u$, A $^3\Sigma_u^+$, $^1\Sigma_u^-$, and B $^3\Sigma_u^-$ states of $O_2$ have been calculated from spectroscopic data by the Rydberg—Klein—Rees method. Curves for the remaining twelve states of $O_2$ dissociating to ground state atoms have been obtained from relations derived from approximate quantum-mechanical calculations, and checked against the meager experimental information available. Two semi-independent calculations have been made, and are in good agreement with each other. The quantum-mechanical relations also lead to an approximate $O_2$—$O_2$ interaction, which is consistent with interactions derived from vibrational relaxation times and from high temperature gas viscosity data.

539.19 : 530.16

HYDRODYNAMIC EQUATIONS FOR THE QUANTUM SYSTEMS OF DIATOMIC MOLECULES. See Abstr. 3456

539.19

### 4246 DIELECTRIC PROPERTIES OF LINEAR POLYAMIDES.

D.W.McCall and E.W.Anderson.

J. chem. Phys., Vol. 32, No. 1, 237-41 (Jan., 1960).

The dielectric constant and loss have been measured for several linear polyamides over a range of frequency and temperature. At low frequencies and elevated temperatures, proton conduction through the amorphous regions gives rise to a Maxwell—Wagner loss, while at high frequencies and high temperatures dipole relaxation of the amide groups contained in the amorphous regions gives rise to a typical loss peak. Nylons 6, 6-6, 6-10, 7-9, 6-9, and 10-1 yield very similar results. The N-methylated derivative of nylon 10-10 exhibits a much smaller direct current conductivity than nylon 10-10 (when compared at temperatures of equivalent chain activity) owing to the absence of amide protons.

539.19 : 532.

### 4247 X-RAY DIFFRACTION STUDY OF BISMUTH POLYME IN AQUEOUS PERCHLORATE SOLUTION.

H.A.Levy, M.D.Danford and P.A.Agron.

J. chem. Phys., Vol. 31, No. 6, 1458-61 (Dec., 1959).

X-ray diffraction study of an aqueous solution of bismuth perchlorate has established the presence of a polymeric species contai ing six bismuth atoms in octahedral arrangement. The bismuth—bismuth distances are 3.70 and 5.23 A.

539.19 : 533.

DIMER FORMATION IN GASEOUS TRANSITION METAL (II) HALIDES. See Abstr. 3566

539.19 : 533.

SECOND VIRIAL COEFFICIENT AND PROPERTIES OF DOUB MOLECULES. See Abstr. 3567

539.1

### 4248 DIMENSIONS OF LONG-CHAIN MOLECULES WITH RESTRICTED INTERNAL ROTATION AND VARIABLE BOND LENGTH AND ANGLE.

W.J.Taylor.

J. chem. Phys., Vol. 32, No. 1, 146-8 (Jan., 1960).

Exact formulas are obtained for the mean square length and radius of an unbranched chain molecule of n equivalent bonds, with restricted internal rotation about each bond and variable bond lengt and angle. It is assumed only that each of the internal coordinates is distributed independently of the others. This model is not entire realistic, but is justified for the bond stretching and bending motion because of the small effect they have on the chain dimensions, show to be of the order of a few tenths of one percent at normal temperatures.

539.1

### 4249 HYDROGEN ION TITRATION CURVE OF A POLYNUCLEOTIDE CAPABLE OF UNDERGOING A HELIX-COIL TRANSITION.

R.F.Steiner.

J. chem. Phys., Vol. 32, No. 1, 215-21 (Jan., 1960).

A theory is developed for the hydrogen ion titration curve of doubly stranded helical polynucleotides for which the two strands are non-identical and very long. It is shown that for pronounced sharpening to occur, the binding (or dissociation) of a proton must favour the rupture of the internucleotide hydrogen bonding, and also the addition to a sequence of ruptured bonds must be energetically favoured over the formation of a new sequence.

539.19

### 4250 THE SECONDARY HYDROGEN ISOTOPE EFFECT.

E.A.Halevi.

Internat. J. appl. Radiation and Isotopes, Vol.7, No.3, 192-7 (Jan., 1960).

Secondary isotope effects are reviewed with particular regard to their interpretation within a consistent scheme. It appears that adherence to formal considerations of vibrational frequency shifts is inadequate for the interpretation of many experimental results, and that these nay be more fruitfully discussed in terms of "electronic" substituent effects, which differ for isotopic molecules by virtue of their slightly different mean configurations.

# SOLID-STATE PHYSICS

539.2

### 4251 IS THERE AN IDEAL CRYSTAL?
E.R.Dobbs.

mer. J. Phys., Vol. 28, No. 3, 243-9 (March, 1960).

An elementary classification of crystals according to their nding forces shows that an ideal crystal, defined as a perfect lat- ce of spherical atoms held together with two-body, central forces, hould be found among the inert gas solids. The calculation of a lat- ce energy from an interatomic potential of the Mie–Lennard-Jones rm is discussed, and the results for the hexagonal and cubic close- acked lattices compared. For argon, it is shown that a (12, 6) teratomic potential, whose constants have been calculated from the rystal parameters at 0°K, can be used to predict both the specific eat of the crystal and the second virial coefficient of the gas over itable ranges of temperature. A comparison of this interatomic otential with existing calculations of the interaction of two argon oms show that the macroscopic properties of argon can be calcu- ted at present from a pair potential, but not directly from the roperties of an argon atom.

539.2

### 4252 $f^2$ CONFIGURATION IN A CRYSTALLINE FIELD.
R.A.Satten and J.S.Margolis.

. chem. Phys., Vol. 32, No. 2, 573-81 (Feb., 1960).

The matrix representation of a 4th and 6th degree octahedral otential in a complete basis of $f^2$ LSJ functions belonging to a articular row of each of the 5 irreducible representations of the ctahedral group $O_h$ is presented. The matrices are 7 × 7, 3 × 3, wo of 9 × 9, and 12 × 12 when spin–orbit and electrostatic inter- ction are included. Bases for the 5 irreducible representations re presented as linear combinations of M states for integral J values anging from 0 to 6. Reduced matrix elements (independent of M r row of representation) are also given including a 2nd degree po- ential as well so that matrices for any other symmetry can eadily be formed in the $f^2$ configuration. Sufficient information is iven to define the phases of the states so that other interactions uch as spin–orbit can readily be included.

539.2 : 539.18

### 4253 HARTREE–FOCK CALCULATIONS FOR $\text{Mn}^{++}$ IN CUBIC FIELDS.
R.E.Watson.

Phys. Rev., Vol. 117, No. 3, 742-7 (Feb. 1, 1960).

Hartree–Fock calculations were carried out for the $\text{Mn}^{2+}$ ion n cubic fields produced by sets of octahedrally placed point charges. The two types of cubic 3d electrons were allowed to have different radial dependence. The relaxation of the constraint of having a single 3d radial function led to effects which were small but which the author believes should be included in any detailed treatment of a paramagnetic ion in a crystalline field.

539.2

### 4254 GENERALIZATION OF CRYSTAL FIELD THEORY TO INCLUDE COVALENT BONDING.
H.S.Jarrett.

J. chem. Phys., Vol. 31, No. 6, 1579-85 (Dec., 1959).

A potential operator with many of the features of the crystal field potential of Bethe (Abstr. 892 of 1930) and Van Vleck (Abstr. 119-20 of 1936) but which explicitly accounts for any degree of covalent bonding between metal and ligand, is derived starting from antisymmetrized molecular orbitals.

539.2

### 4255 ON THE BORON–NITROGEN DONOR–ACCEPTOR BOND.
S.Geller.

J. Phys. Chem. Solids, Vol. 10, No. 4, 340-1 (Aug., 1959).

Comparison of various B–N bonds with each other and with C–C bonds gives rise to the prediction that the heat of sublimation of cubic BN into single atoms should be less than half that of diamond. R.F.Peart

539.2

### 4256 THE VALENCE STATE OF METALLIC LEAD.
W.Hume-Rothery.

Canad. J. Phys., Vol. 37, No. 12, 1565 (Dec., 1959).

Pearson (Abstr. 5015 of 1958) suggested that, since dilute solutions of Cd are much more effective than dilute solutions of Sn in changing the electrical properties of lead, lead is tetravalent in the metallic state. Considerations of electronic structure show that this argument is open to criticism, and that the phenomenon is connected with the relatively large energy difference between the 6s and 6p levels in the Pb free atom. L.Pincherle

539.2 : 536.7

### 4257 COHESIVE ENERGY AND EQUATION OF STATE OF IRON AT HIGH PRESSURE [$10^9$ atm].
J.Henry.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 45, No. 6, 553-74 (1959). In French.

Evaluated using the orthogonalized plane waves method. A self-consistent calculation is developed to obtain the crystal potential (supposed spherical). The cohesive energy is about 300 times as great (in modulus) as the normal value (~100 kcal $\text{mole}^{-1}$). The pv curve lies close to the extrapolated experimental results (shock waves experiments) and looks closer to reality than the points obtained by the Thomas–Fermi approximation.

539.2

### 4258 SURFACE ENERGIES OF METAL CRYSTALS.
I.Pfeiffer.

Z. angew. Phys., Vol. 11, No. 12, 477-84 (Dec., 1959). In German.

The experimental methods of determining surface energies of metal crystals are critically discussed. The theoretical calculations of Friedel [Acta metallurgica, Vol. 1, 79 (1953)] and Skapski [Acta metallurgica, Vol. 4, 576 (1956)] are used to determine the surface energy of the (110) and (100) planes of Fe crystals. Discrepancies between theory and experiment are discussed. J.Franks

539.2

### 4259 MINIMUM MOLAR GIBBS FREE ENERGY AND SMALL DEVIATIONS FROM STOICHIOMETRY IN CRYSTALLINE BINARY COMPOUNDS.
R.F.Brebrick.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 43-5 (Sept., 1959).

It is shown that the minimum molar Gibbs free energy for a binary compound showing small deviations from the stoichiometric composition can be calculated from the standard free energy of formation. The significance of the minimum-free-energy curve on a pressure-temperature projection of the phase diagram is discussed. In particular, its displacement from the intrinsic curve may serve to establish another relation among the energy parameters defining the crystal model.

## Lattice Dynamics

539.2

### 4260 MICROSCOPIC PROPERTIES AND ATOMIC STRUCTURE OF SOLIDS.
K.Schäfer.

Z. Electrochem., Vol. 63, No. 8, 863-75 (1959). In German.

A general review of some aspects of lattice vibrations, their frequency spectra, and the melting process. P.T.Landsberg

539.2

### 4261 ON THE LATTICE VIBRATIONS AND SPECIFIC HEAT OF KCl AND NaCl AT LOW TEMPERATURES.
S.O.Lundqvist, V.Lundström, E.Tenerz and I.Waller.

Ark. Fys., Vol. 15, Paper 16, 193-206 (1959).

The frequency spectrum at 0°K and the specific heat at low temperatures are calculated in three different approximations. The Born model is shown to give results which are definitely not in accordance with experiments. A second approach, which has some theoretical support in the Heitler–London treatment of ionic crystals, gives considerably better results. This approach is supplemented by taking the polarizability of the ions into account. The polarization is shown to have a strong influence upon the frequency distribution. The results in this approximation are those which best agree with the observed specific heats, although some discrepancy still remains.

539.2

### 4262 REMARKS ON THE VIBRATIONAL PROPERTIES OF ONE-DIMENSIONAL IONIC LATTICES.
G.Weiss.

Bull. Res. Coun. Israel, Vol. 7F, No. 4, 165-70 (Dec., 1958).

Two models are analysed: one with a long-range interaction of the form $\exp(-\lambda r_{jk})$ and the other of the form $1/r_{jk}$ where $r_{jk}$ is the distance between the j-th and k-th atoms. A dispersion relation and frequency spectrum can be found for these models in closed form.

One finds, as in the case of a Coulomb force model, that no more than two singularities appear in the spectrum. For the two models, the nature of the singularities can easily be investigated because of the simple form of the dispersion relation.

539.2

### 4263 THE EFFECT OF TEMPERATURE ON PROPAGATION OF ELECTROMAGNETIC WAVES IN CRYSTALS IN WHICH EXCITONS ARE FORMED. M.S.Brodin and A.F.Lubchenko.

Optika i Spektrosk., Vol. 7, No. 1, 83-8 (July, 1959). In Russian.

Discusses equations which give the refractive (n) and absorption ($\chi$) indices for crystals in which excitons may be formed. These equations are given for weak coupling of excitons with the lattice vibrations. It is shown that with increase of temperature these equations tend to assume the form of the usual equations for n and $\chi$ in classical crystal optics. This tendency increases with the increase of the effective exciton mass and with the increase of the strength of the exciton—phonon interaction. Using Kramers—Kronig formulae the authors calculated the dispersion curves for anthracene and stilbene and compared the calculated curves with experimental ones. It was found, in agreement with the above conclusions, that the differences between the calculated and experimental curves become smaller as temperature increases. A.Tybulewicz

539.2

### 4264 IRREVERSIBLE PHENOMENA DUE TO ISOTOPIC SUBSTITUTION IN CRYSTALS. C.George.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 45, No. 3, 239-50 (1959). In French.

The methods of Prigogine are applied to a general discussion of the effects of random isotopic substitutions in crystals, treated as a two-phonon interaction process. J.Hawgood

539.2

### 4265 ON THE INFLUENCE OF THE COMPLEXITY OF THE "ELEMENTARY ACT" ON THE TEMPERATURE DEPENDENCE OF THE VELOCITY OF THE ATOMIC MOVEMENT PROCESS IN THE SOLID PHASE AND ON THE MAGNITUDE OF THE APPARENT ACTIVATION ENERGY. V.I.Arkharov.

Fiz. Metallov i Metallovedenie, Vol. 7, No. 2, 209-13 (1959). In Russian.

The variation of the number (a) of atoms involved in an "elementary act" of atomic movement is calculated as a function of temperature and stored energy of deformation of the lattice (e.g. at the melting point, a = coordination number + 1). Hence the influence of temperature and deformation on the activation energy for rate processes involving atomic movements is calculated. [English summary: PB 141126T-9, obtainable from Office of Technical Services, U.S. Dept.of Commerce, Washington,D.C., U.S.A.]. A.F.Brown

539.2

### 4266 SPECIFIC HEATS OF $NiCl_2.6H_2O$ AND $CoCl_2.6H_2O$ BETWEEN 1.4° AND 20° K.

W.K.Robinson and S.A.Friedberg.

Phys. Rev., Vol. 117, No. 2, 402-8 (Jan. 15, 1960).

Lambda-type anomalies were observed at 5.34° K and 2.29° K for $NiCl_2.6H_2O$ and $CoCl_2.6H_2O$, respectively, associated presumably with antiferromagnetic—paramagnetic transitions. It has been possible in each case to separate out the magnetic contribution to the specific heat and thus to compute the total magnetic entropy gained in the transition from the fully ordered to completely disordered condition. This quantity was found to be given accurately by $R \ln(2S + 1)$ with $S = \frac{1}{2}$ for $Co^{2+}$ and $S = 1$ for $Ni^{2+}$. Short-range order is particularly pronounced in these substances, the fraction of the total magnetic entropy gained above the Neel point being 0.52 for $CoCl_2.6H_2O$ and for 0.40 for $NiCl_2.6H_2O$. Other features of the anomalies are discussed.

539.2 : 536.63

### 4267 THE ELECTRONIC SPECIFIC HEATS OF SOME NICKEL COBALT ALLOYS. J.C.Walling and P.B.Bunn.

Proc. Phys. Soc., Vol. 74, Pt 4, 417-23 (Oct. 1, 1959).

Low-temperature specific-heat measurements on nickel, cobalt and four alloys of nickel and cobalt are described. It is shown, as a result of these measurements, that the 3 d-band is unlikely to be parabolic, as has frequently been assumed, at the Fermi limit in nickel. Assuming that the relative magnetization is unity for nickel and the alloys, the shape of the 3 d-band is calculated from the measured values of $\gamma$, the coefficient of electronic heat capacity, the resultant curve being in good agreement with the theoretical curve obtained by Fletcher in 1952 at the nickel-rich end.

539.2 : 536.63

### 4268 THE ATOMIC HEAT $C_p$ OF PURE MAGNESIUM, AND MAGNESIUM CONTAINING HYDROGEN, BETWEEN 12 AND 300° K. W.Mannchen and K.Bornkessel.

Z. Naturforsch., Vol. 14a, No. 10, 925-6 (Oct., 1959). In German.

Results, shown graphically, of measurements made with a vacuum calorimeter on pure Mg and on Mg with a hydrogen content of 21 $cm^3$ per 100 g of metal (at s.t.p.) are briefly reported. S.Weintroub

539.2 : 536.63

### 4269 THE ATOMIC HEAT OF GALLIUM BETWEEN 6 AND 21° K. W.Eichenauer and M.Schulze.

Z. Naturforsch., Vol. 14a, No. 11, 962-6 (Nov., 1959). In German.

The atomic heat $C_p$ of 158.62 g of 99.95% pure Ga was measured at approximately 0.2° K intervals using a vacuum calorimeter. The apparatus is described and the results are tabulated and graphically compared with previous data. Between 6° and 11° K, $C_p = 10^{-5}(0.577 \pm 0.054)\,T^4$ cal(gram atom)$^{-1}$ deg$^{-1}$K. The entropy at 25° C, obtained by graphical integration, is stated to be $9.755 \pm 0.05$ Clausius (gram atom)$^{-1}$. S.Weintroub

539.2 : 536.41

### 4270 THE THERMAL EXPANSION OF SOLIDS. G.C.Fletcher.

Austral. J. Phys., Vol. 12, No. 3, 237-47 (Sept., 1959).

From the theory of normal vibrations of a lattice, a practical means of obtaining the equation of state of an ionic solid is developed from which the thermal expansion can be derived. Using previous work by Kellermann (1940), application is made to the case of sodium chloride and the results compared with experiment. Possible reasons for the discrepancy between theory and experiment, which is very large at high temperatures, are discussed. The variation with temperature of the specific heat at constant volume and the isothermal compressibility are also investigated.

539.2 : 536.41

### 4271 ON THE LATTICE THEORY OF EXPANSION. M.Blackman.

Proc. Phys. Soc., Vol. 74, Pt 1, 17-26 (July 1, 1959).

An investigation has been made of the expansion coefficient of two-dimensional lattices—ionic lattices and the close packed hexagonal lattice with central forces. A survey has been made of the Gruneisen constants $\gamma_\nu$ of a representative set of vibrations in reciprocal space. From these a set of functions are constructed from which the variation of the Grüneisen constant $\gamma$ can be calculated, and which also permit one to see the reasons for the variation. It is shown that the ionic lattices are characterized by a large spread in $\gamma_\nu$ values, this being in the main due to the lower of the two frequenc branches. In the hexagonal lattice the distribution of $\gamma_\nu$ values is in comparison, very limited and the Grüneisen assumption of a single constant can be justified in this case.

539.2

### 4272 INTRODUCTION TO SOFT X-RAY SPECTROSCOPY. E.R.Pike.

Amer. J. Phys., Vol. 28, No. 3, 235-42 (March, 1960).

The presentation of some fundamental ideas concerning the behaviour of electrons in solids is followed by an outline of the theory of the use of X-ray methods for obtaining information about these electrons. Experimental methods are discussed briefly and some recent trends and developments in the subject are reviewed.

539.2

### 4273 WAVE FUNCTIONS AND EFFECTIVE HAMILTONIAN FOR BLOCH ELECTRONS IN AN ELECTRIC FIELD.

G.H.Wannier.

Phys. Rev., Vol. 117, No. 2, 432-9 (Jan. 15, 1960).

Following up an earlier communication [(Abstr. 2269 of 1959) and Phys. Rev., Vol. 101, No. 6, 1835 (March 15, 1956)], wave-functions are constructed which satisfy the Schrödinger equation for a potential which is a sum of a periodic and a uniform field term. The wave-functions are Houston modifications of Bloch type functions the Bloch functions form an orthogonal set whose members are fully determined except for phase. The theory exhibits them in the form of power series in the field strength; the unmodified Bloch band functions form the zero order term of that series. The solutions themselves do not allow for a Zener effect, but the fact that they are only given as power series in E may imply that there is a remainder term causing interband transitions; it would have to be asymptotically smaller than any power of E. Instead of constructing time dependent solutions of the Schrödinger equation one can take the time independent functions to construct an effective Hamiltonian for electrons in one band. Certain indeterminacies are attached to this form of representation; it is shown, however, that final physical answers are unique. The study furnishes an incidental proof that k-space is a finite space consisting in its entirety of what is customarily called the first Brillouin zone. An appendix treats the case of degenerate bands; such bands have singularities in k-space even in the absence of a field. The difficulty is circumvented by working with a set which is not yet diagonalized but free of singularities; these intermediate functions can be continued as power series in E in the same way as nondegenerate band functions.

539.2

### 4274 WAVE FUNCTIONS FOR IRON D BAND.

J.H.Wood.

Phys. Rev., Vol. 117, No. 3, 714-18 (Feb. 1, 1960).

The one-electron wave-functions for the d-band of body-centred iron are examined and found to have significantly different character, depending on their energy location in the band. The bottom of the band is associated with diffuse wave-functions, while the top is associated with more compact atomic-like functions. A smooth transition from one behaviour to the other occurs as the energy is varied. This gives substantiation to recent descriptions of transition metals which have been based on "low d" assignments; here this is explained on the basis that a significant fraction of the d electrons in a solid do not "look" like atomic d electrons at all.

539.2

### 4275 THE SHIELDING OF A FIXED CHARGE IN A HIGH-DENSITY ELECTRON GAS.

J.S.Langer and S.H.Vosko.

J. Phys. Chem. Solids, Vol. 12, No. 2, 196-205 (Jan., 1960).

The shielding of a small fixed charge in a high-density electron gas is calculated by means of a technique similar to that used by Gell-Mann and Brueckner for calculating the correlation energy. A closed expression for the density of displaced electrons is derived and evaluated numerically for several densities of the electron gas. An asymptotic form is also given.

539.2 : 530.16

### 4276 NOTE ON THE "TORON" FORMALISM DEVELOPED BY MONTROLL AND WARD.

R.Abe.

Progr. theor. Phys., Vol. 21, No. 6, 941-2 (June, 1959).

This letter quotes a "linked-cluster" expansion for the grand partition function which greatly simplifies Montroll and Ward's calculation (Abstr. 5665 of 1958) for the high-density electron gas problem. O.Penrose

539.2

### 4277 A SELF-CONSISTENT CALCULATION OF THE GRAPHITE $\pi$ BAND.

T.E.Peacock and R.McWeeny.

Proc. Phys. Soc., Vol. 74, Pt 4, 385-94 (Oct. 1, 1959).

The approximate self-consistent field theory, recently developed in calculations of molecular wave-functions, is applied to a two-dimensional crystal — the graphite layer. The crystal orbitals for the $\pi$-electrons are construcued from atomic orbitals, as in the usual tight-binding approximation, but the methods of many-electron theory are used in setting up the self-consistent field. Matrix elements of the one-electron Hartree—Fock Hamiltonian (which in the usual tight-binding model are identified empirically) are expressed in terms of the $\pi$-electron density matrix, whose elements may be evaluated by integration over the occupied region of k-space, and are systematically adjusted until Hamiltonian and charge density are self-consistent. The results, besides being of intrinsic interest, suggest that with the further development of automatic computation similar calculations on three-dimensional crystals will become feasible.

539.2

### 4278 STUDIES OF POLARON MOTION. I. THE MOLECULAR-CRYSTAL MODEL.

T.Holstein.

Ann. Phys. (New York), Vol. 8, No. 3, 325-42 (Nov., 1959).

A model for polaron motion is described which incorporates, in a simplified form, the principal physical features of the problem. The (crystalline) medium, within which a single excess electron (or hole) is contained, is taken to be a one-dimensional molecular crystal, consisting of diatomic molecular sites; each site possesses a single vibrational degree of freedom, represented by the deviation, $x_n$, of its internuclear separation from equilibrium. The motion of the electron in this medium is treated by a tight-binding approach, in which the wave-function is represented as a superposition of local "molecular" functions, $\phi(r - na, x_n)$. In line with the $x_n$ dependence of the $\phi$'s, it is also assumed that the "local" electronic energy, $E_n$ (which, in the conventional tight-binding theory, has one and the same value for all sites) depends (linearly) on $x_n$. This dependence gives rise to electron—lattice interaction; alternatively, it may be regarded as removing the electronic translational degeneracy, characteristic of the undistorted crystal, and thereby providing the possibility for electron trapping. On the basis of this model, the zeroth order adiabatic treatment of the polaron problem is developed. For values of the parameters such that the linear dimension of the polaron is large compared with a lattice spacing ("large" polaron), an exact solution is obtained; the correspondence between it and Pekar's zeroth-order solution is established. The conditions under which the size of the polaron becomes comparable to a lattice spacing ("small" polaron) are discussed. A description is given of an alternate molecular-crystal model which, in the case of the large polaron, is completely equivalent to the continuum-polarization model of conventional polaron theory.

539.2

### 4279 STUDIES OF POLARON MOTION . II. THE "SMALL" POLARON.

T.Holstein.

Ann. Phys. (New York), Vol. 8, No. 3, 343-89 (Nov., 1959).

The model described in the preceding abstract is analysed for the case in which the electronic-overlap term of the total Hamiltonian is a small perturbation. In zeroth order (i.e. in the absence of this term) the electron is localized at a given site, p. The vibrational state of the system is specified by a set of quantum-numbers $N_k$ giving the degree of excitation of each vibration-mode; the latter differ from the conventional modes in that in each of them, the equilibrium displacement, about which the system oscillates, depends on the location of the electron. The presence of a non-vanishing electronic-overlap term gives rise to transitions in which the electron jumps to a neighboring site ($p \to p \pm 1$), and in which either all of the $N_k$ remain unaltered ("diagonal" transitions) or in which some of them change by ±1 ("nondiagonal" transitions). The two types of transition play fundamentally different roles. At sufficiently low temperatures, the diagonal transitions are dominant. They give rise to the formation of Bloch-type bands whose widths are each given by the product of the electronic-overlap integral and a vibrational overlap-integral, the latter being an exponentially falling function of the $N_k$ (and, hence, of temperature). In this low-temperature domain, the role of the nondiagonal transitions is essentially one of scattering. In the absence of other scattering mechanisms, such as impurity scattering, they determine the lifetimes of the polaron-band states and, hence, the mean free path for typical transport quantities, such as electron diffusivity. With rising temperature, the probability of the off-diagonal transitions goes up exponentially. This feature, together with the aforementioned drop in bandwidth, results, for example, in an exponentially diminishing diffusivity. Eventually, a temperature, $T_t \sim \frac{1}{2}$ the Debye $\theta$, is reached at which the energy uncertainty, $\hbar/\tau$, associated with the finite lifetime of the states, is equal to the bandwidth. At this point, the Bloch states lose their individual characteristics (in particular, those which depend upon electronic wave number); the bands may then be considered as "washed out". For temperatures $> T_t$, electron motion is predominantly a diffusion process. The elementary steps of this process consist of the random-jumps between the neighboring sites associated with the nondiagonal transitions. In conformity with this picture, the electron diffusivity is, apart from a numerical factor, the product of the square of the lattice distance and the total nondiagonal transition probability, and is therefore an exponentially rising function of temperature. The limit $J_{max}$ of the magnitude of the electronic overlap term, beyond which the perturbation treatment of the present paper becomes inapplicable, is investigated. For representative values of the parameters entering into the theory, $J_{max} \sim 0.12$ eV and 0.035 eV for the extreme cases of (a) width of the ground-state polaron-band and (b) high-temperature site-jump probabilities (these numbers correspond to electronic bandwidths of 0.24 eV and 0.07 eV, respectively). For electronic bandwidths in excess of these limits, a treatment based on the adiabatic approach is required; preliminary results of such a treatment are given for these two cases.

539.2

### 4280 THE POTENTIAL ENERGY OF THE ELECTRON-HOLE INTERACTION IN IONIC CRYSTALS.

L.Hrivnák.

Czech. J. Phys., Vol. 9, No. 4, 439-45 (1959). In German.

The potential energy of the electron-hole interaction is derived and the effect of interaction with optical lattice vibrations is discussed. J.Franks

539.2 : 539.12

POSITRON ANNIHILATION IN METALS. See Abstr. 3960

539.2

4281 THE THEORY OF ANNIHILATION OF EXCITONS, ACCOMPANIED BY THE CREATION OF DEFECTS OF ANOTHER TYPE AND OF CURRENT CARRIERS. M.Trlifaj.
Czech. J. Phys., Vol. 9, No. 4, 446-59 (1959). In German.

The process of exciton annihilation at vacant lattice sites and at F-centres is investigated theoretically. The cases considered are those in which another type of centre is created, together with another charge carrier. General expressions for the cross-section of the processes are derived by means of a quasi-classical approximation and the results obtained are briefly discussed.

R.Parker

539.2

4282 THE ATTACHMENT OF EXCITONS TO DEFECTS IN CRYSTAL LATTICES. M.Trlifaj.
Czech. J. Phys., Vol. 9, No. 5, 562-71 (1959). In German.

The process of attachment of excitons to vacancies and F-centres in ionic crystals is studied. The motion of excitons under the influence of vacancies and F-centres is considered in the adiabatic approximation. The effective cross-section for attachment of excitons to vacancies and F-centres is calculated and discussed using classical methods.

J.W.Leech

539.2

4283 ON THE POSSIBILITY OF CAUSING A DIRECTED MIGRATION OF EXCITONS. S.Nikitine and H.Haken.
C.R. Acad. Sci. (Paris), Vol. 250, No. 4, 697-9 (Jan. 25, 1960). In French.

The energy of an exciton in a magnetic field is compared with the thermal energy at very low temperatures. The forces acting on an exciton in a magnetic field gradient, which are small for diamagnetic excitons and larger for paramagnetic excitons, can produce a directed migration. Some experiments to verify the theory are suggested.

J.Franks

539.2

4284 QUANTUM THEORY OF TRANSPORT IN A MAGNETIC FIELD. P.N.Argyres.
Phys. Rev., Vol. 117, No. 2, 315-28 (Jan. 15, 1960).

A quantum-mechanical theory of transport of charge for an electron gas in a magnetic field is presented that takes account of the quantization of the electron orbits. A transport equation for the necessary elements of the density matrix is developed for arbitrary values of the magnetic field. The scattering is taken to be elastic and is treated only in the Born approximation. The effect of both the magnetic and electric fields on the collisions is taken into account. The influence of the latter has been neglected in previous theories. It is proved, however, to be important in high magnetic fields. It is established that the effect of a transverse electric field on the scattering can be described as the tendency of the electrons to "relax" to a distribution characteristic of thermal equilibrium in the presence of the electric field. Previous theories of transport for large Hall angles are consistent with this theory. They can be obtained as a special solution, found by iteration, of this transport equation. The special case of isotropic scattering has been considered in detail. In this case it is demonstrated that for small enough magnetic fields the usual classical result obtains.

539.2

4285 SOME OBSERVATIONS ON NUCLEAR ALIGNMENT IN COBALT METAL. J.M.Daniels and M.A.R.LeBlanc.
Canad. J. Phys., Vol. 37, No. 11, 1321-4 (Nov., 1959).

A single crystal of cobalt metal containing radioactive $Co^{60}$ was cooled to about 0.04°K and the $\gamma$-ray angular distribution from the $Co^{60}$, which had become aligned by the h.f.s. field, was studied. This showed an anisotropy of about 12%. This result is discussed in relation to other authors' work on the h.f.s. in cobalt metal.

M.A.Grace

### Defect Properties

539.2

4286 METHOD OF DECORATION OF SURFACES OF IONIC CRYSTALS. APPLICATION TO THE STUDY OF DISLOCATIONS AND POINT DEFECTS OF ALKALI HALIDES. C.Sella, P.Conjeaud and J.J.Trillat.
C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 1987-90 (Nov. 16, 1959). In French.

Gold evaporated on to NaCl, KCl and KBr at an elevated temperature nucleates at preferred sites. The distribution of these sites may be studied by removing the nuclei on a carbon supporting film and observing them in the transmission electron microscope.

J.W.Menter

539.2

4287 FUNDAMENTAL CONCEPTS OF THE THEORY OF DISLOCATIONS. B.Gruber.
Czech. J. Phys., Vol. 9, No. 6, 701-9 (1959).

A systematic treatment of the geometrical foundations of dislocation theory. The author emphasizes that it differs from the well-known paper by Frank (Abstr. 8345 of 1951) by its smaller range and in the definition of the "good region". The author claims his method is less general but automatically avoids topological oddities ("Moebius crystals") which Frank has to eliminate separately.

J.W.Leech

539.2

4288 CALORIMETRIC STUDIES ON ANNEALING QUENCHED-IN DEFECTS IN GOLD. W.DeSorbo.
Phys. Rev., Vol. 117, No. 2, 444-50 (Jan. 15, 1960).

The energy evolved on annealing quenched-in defects in gold was measured with a high-precision, fast-adiabatic, microcalorimeter. The energy can be described by an equation,

$$\Delta E_T = B \exp(-E_f/kT_Q),$$

where $\Delta E_T$ is the total energy evolved for a quench from temperature, $T_Q$. B is a constant equal to $(4.5 \pm 1.0) \times 10^4$ cal/g-atom. $E_f$, the energy of formation of the defect, is equal to $0.97 \pm 0.1$ eV, in good agreement with the value reported by Bauerle and Koehler from resistometric studies. The activation energy of motion of the defects has a temperature dependence confirming the results obtained resistometrically, i.e., $E_m = 0.73$ and $0.62$ eV at $T_Q = 820°$ and 920° C, respectively. Assuming that the quenched-in defects are single vacancies, the energy measurements can be combined wit the resistivity data of Bauerle and Koehler to give the resistivity increase per one atomic percent vacancies, $\Delta\rho_0/\Delta E_T/E_f$, using only experimentally derived quantities. This ratio equals $1.8_0 \pm 0.6$ μohm cm/at.%. The volume increase of the gold lattice per vacancy determined from the ratio, $\Delta\rho_0/\Delta E_T/E_f$, and Bauerle and Koehler's relationship between resistivity and fractional volume change during recovery, is $0.5_7 \pm 0.05$ in good agreement with recent theoretical work of Tewordt.

539.2 : 539.3

4289 ASPECTS OF THE THEORIES OF DISLOCATION MOBILITY AND INTERNAL FRICTION. J.Lothe.
Phys. Rev., Vol. 117, No. 3, 704-8 (Feb. 1, 1960).

The theory of dislocation mobility is reconsidered, and it is concluded that the interaction between thermal waves and a moving vibrating dislocation causes a drag to the first order in v/c. Modifications of the Seeger–Donth theory for the Bordoni peak are suggested. When account is taken of the diffusion of kinks, general agreement with experiment is obtained. The theory of internal friction in the microwave region is briefly reviewed and discussed. No thorough comparison with experimental data has been performed.

539.2

4290 MEASUREMENT OF THE ENERGY OF FORMATION OF A LATTICE DEFECT BY ELECTRON IRRADIATION IN SOME $A^{III}B^{V}$ COMPOUNDS. R.Bäuerlein.
Z. Naturforsch., Vol. 14a, No. 12, 1069-73 (Dec., 1959). In German.

The energy of formation of lattice defects in InP, InAs and GaAs was obtained by measuring the voltage threshold above which recombination centres were produced in p–n barrier layers. The threshold potentials were between 100 and 300 kV and corresponded to defect formation energies of 9.25 eV for P in InP, 9.35 eV for As in InAs, and 9.1 and 9.8 eV for Ga and As in GaAs.

J.Franks

539.2

4291 X-RAY MEASUREMENT OF THE DISTORTION FIELD OF A SINGLE DISLOCATION.
U.Bonse, E.Kappler and F.J.Simon.
Z. Naturforsch., Vol. 14a, No. 12, 1079-80 (Dec.,1959). In German.

See Abstr. 6268-9 (1959). The double-crystal method is applied to dislocations in germanium, and the interpretation of a photograph is given.

A.R.Stokes

539.2 : 77

### 4292 EXPERIMENTS ON THE INFLUENCE OF STRUCTURAL SURFACE DEFECTS ON THE DEVELOPABILITY AND GHT SENSITIVITY OF SILVER HALIDE SINGLE CRYSTALS.

Klein and R.Matejec.

angew. Phys., Vol. 12, No. 1, 26-33 (Jan., 1960). In German.

Examination of etch pits on large single crystals indicated that otolytic silver forms preferentially at structural surface defects. ese surface defects are revealed both by direct etching and by eloping the surface, followed by dissolving away the silver with d. Protecting colloids such as gelatine reduce the developability the surface defects. B.T.M.Willis

539.2

### 4293 ON SURFACE LAYERS ON $BaTiO_3$ SINGLE CRYSTALS.

V.Dvořák.

ech J. Phys., Vol. 9, No. 6, 710-16 (1959).

The possibility of explaining the existence of a surface layer on $TiO_3$ crystals by the presence of Schottky defects in the crystal is vestigated. The magnitude of the potential difference between the rface and the interior of the crystal and the thickness of the surce layer, which at temperatures of over 400°C agrees with the easured values, are calculated for the cubic phase from a simplied ionic model.

539.2

### 4294 MEASUREMENTS OF EQUILIBRIUM VACANCY CONCENTRATIONS IN ALUMINUM.

O.Simmons and R.W.Balluffi.

ys. Rev., Vol. 117, No. 1, 52-61 (Jan. 1, 1960).

Measurements of change in length and change in lattice paraeter were made at identical temperatures on 99.995% aluminium the temperature range 229° to 656°C. Length changes, $\Delta L$, were easured on an uncontrained horizontal bar sample using a rigid ir of filar micrometer microscopes. X-ray lattice parameter anges, $\Delta a$, were observed using a high-angle, back-reflection, tating-single-crystal technique. The measurements are compared earlier work. The relative expansions $\Delta L/L$ and $\Delta a/a$ were ual within about $1 : 10^5$ from 229° to 415°C. At higher temperares additional atomic sites were found to be generated: the fference between the two expansions could be represented by

$$3(\Delta L/L - \Delta a/a) = \exp(2.4) \exp(-0.76\ \mathrm{eV}/kT).$$

t the melting point (660( C the equilibrium concentration of addition sites is $3(\Delta L/L - \Delta a/a) = 9.4 \times 10^{-4}$. This result is independent f the detailed nature of the defects, for example, the lattice relaxtion or degree of association. The nature of the defects is conidered and it is concluded that they are predominantly lattice acancies; it is estimated that the divacancy contribution at the elting point may well be less than about 15%, corresponding to divacancy binding energy $\leq 0.25$ eV. The observed formation nergy agrees with the values obtained by quenching techniques nd by interpretation of the high-temperature electrical resistivity f identical material (Abstr. 4315 of 1960). The present work is he first direct measurement of formation entropy; the value is ear that expected from theoretical considerations. The contribution f the thermally generated defects to other physical properties at igh temperatures is considered briefly.

539.2 : 536.7

### 4295 THERMODYNAMICS AND FORMULATION OF REACTIONS INVOLVING IMPERFECTIONS IN SOLIDS.

F.A.Kröger, F.H.Stieltjes and H.J.Vink.

Philips Res. Rep., Vol. 14, No. 6, 557-601 (Dec., 1959).

Two types of formulation of reactions involving imperfections in solids are analysed and compared with each other. It appears that in Schottky's system, the amount-of-substance variables mostly refer to relative building units. Therefore true thermodynamic potentials can be assigned to them and they also can appear as components in the phase rule. In an alternative system the amount-of substance variables do not refer to building units, but to structure elements and to associates between them. To those no true thermodynamic potential can be assigned. However, by introducing virtual thermodynamic potentials for them, all problems can be dealt with, often in a much more convenient way than with the other type of formulation. Also, appearing as quasi-components in the phase rule, they facilitate its handling greatly. This is illustrated by treating with the aid of the structure-element system various cases of discorder. For the description of those properties of a crystal which are not related to the thermodynamics of reactions, the use of structure elements is also of advantage.

539.2 : 539.12

### 4296 SCREENING OF POINT SINGULARITIES IN METALS, WITH PARTICULAR REFERENCE TO POSITRON ANNIHILATION.

B.Donovan and N.H.March.

J. Phys. Chem Solids, Vol. 11, No. 1-2, 68-72 (Sept., 1959).

The treatment of point singularities in metals initiated by Mott yields an infinitely large electronic density at a positive point charge, owing to the failure of the Thomas–Fermi approximation in this region. In the physically interesting problems involving positron annihilation, the positron lifetime depends on the electron density at the positron, and to obtain a useful result it is necessary to improve the statistical treatment. The present work discusses the modifications resulting from the introduction of von Weizsäcker's correction. In the high-density limit, an analytical development can be given that reveals the essential changes thus brought about. For real metallic densitites, however, a laborious numerical calculation is necessary; this has been done for a unit positive charge embedded in an electron gas of density equal to that of the valence electrons in copper. The electron density at the point charge is eight or nine times the average electron density, indicating a positron lifetime of $(1.8 \pm 0.2) \times 10^{-10}$ sec. Comparison is made with the previous treatment of positron lifetimes by Daniel and Friedel (Abstr. 6130 of 1958). Brief reference is also made to the general subject of impurities and imperfections in the light of the present findings.

539.2

### 4297 ON COLOUR CHANGES IN $BaTiO_3$ SINGLE CRYSTALS IN HYDROGEN ATMOSPHERES AT HIGH TEMPERATURES.

H.T.Arend and P.Coufová.

Czech. J. Phys., Vol. 9, No. 6, 751-2 (1959).

Absorption spectra are shown of $BaTiO_3$ single crystals heated to various temperatures in dry and moist $H_2$ atmospheres. Heating in dry $H_2$ causes a considerable increase in absorption due to colour centre formation, which is probably connected with the production of oxygen vacancies. J.Franks

539.2

### 4298 THE HYPERFINE STRUCTURE OF THE $V_t$-CENTER.

M.H.Cohen, W.Känzig and T.O.Woodruff.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 120-30 (Sept., 1959).

The structure of a new electron deficient colour centre (V-centre) in LiF has been determined from its paramagnetic-resonance hyperfine spectrum. The electron deficiency is localized on three fluoride ions which form an obtuse isosceles triangle lying in a (001) plane with the height along a [110] direction. The orbital of the unpaired electron is primarily determined by the crystalline field and is of the $\pi$-type, in contrast to previously discussed V-centres. There is evidence that the electron deficiency is associated with an aggregate of three vacancies, so that the charge is compensated.

539.2

### 4299 COLOUR CENTRES PRODUCED BY RADIATION IN SILICA GEL.

H.W.Kohn.

Nature (London), Vol. 184, 630-1 (Aug. 22, 1959).

The radiation enhancement (by $\gamma$ or X-rays) of catalytic activity in silica gel is also accompanied by coloration of the gel even for small doses ($10^{19}$ eV/g). The colour is stable to light and to temperature below 250°C but bleaches immediately on contact with excess hydrogen or ethylene; similar but less rapid bleaching is observed for water vapour and ammonia but not for oxygen. The effect of hydrogen is strongly temperature dependent and an activation energy is involved. Further detailed studies might suggest that the colour centres are positive holes associated with excess oxygen but serious differences in adsorption and catalytic exchange site concentrations with given doses are found in contrast to the correlation between colour centre bleaching and adsorption of hydrogen.

G.F.J.Garlick

539.2

### 4300 ELECTRON SPIN RESONANCE OF F-CENTRES IN RUBIDIUM HALIDE CRYSTALS.

H.C.Wolf and K.H.Hausser.

Naturwissenschaften, Vol. 46, No. 23, 646-7 (1959). In German.

Broad resonance spectra were obtained for RbBr (half width 380 Oe) and RbI (half width 640 Oe). The RbCl spectrum has a fine structure, the interaction between electron and $Rb^+$ ion being large compared with the $Cl^-$ ion interaction. Effects of radiation and temperature treatment on the spectrum are discussed. J.Franks

539.2

### 4301 F-CENTER GROWTH CURVES.

P.V.Mitchell, D.A.Wiegand and R.Smoluchowski.
Phys. Rev., Vol. 117, No. 2, 442-3 (Jan. 15, 1960).

It is shown that the increase in the density of F centres in KCl due to X-ray irradiation can be described kinetically by considering two independent groups of negative ion vacancies. One group is composed of vacancies in the lattice before irradiation, while the other is composed of vacancies generated during the irradiation. It is concluded from the difference in the electron capture cross-sections for the two groups of vacancies and the intensity dependence of the rate of generation of new vacancies that the vacancies are generated at dislocations by a multiple ionization process.

539.2

### 4302 THE DIFFUSION OF LITHIUM IN SILICON.

Yu.M.Shashkov and I.P.Akimchenko.
Dokl. Akad. Nauk SSSR, Vol. 128, No. 5, 937-9 (Oct. 11, 1959).
In Russian.

The diffusion of lithium in silicon was examined as a function of temperature from 500 to 1000°C, and an expression obtained for the diffusion coefficient. K.N.R.Taylor

539.2

### 4303 THE INFLUENCE OF MINOR IMPURITIES ON THE DIFFUSION COEFFICIENT IN POLYCRYSTALLINE MATERIALS. II.

V.I.Arkharov, S.M.Klotsman and A.N.Timofeev.
Fiz. Metallov i Metallovedenie, Vol. 6, No. 2, 255-60 (1958). In Russian.

Tracer measurements show that small amounts of Be lead to an acceleration of the intercrystalline diffusion in polycrystalline Cu. The change of diffusion coefficient of silver in copper alloy with 0.1% Be depends on previous treatment which alters the distribution of Be between the grains and the intercrystalline transition zone. The data are used to discuss the adsorption activity of small additions of Be in Cu, and the temperature dependence of enrichment of the intercrystalline zone. The possibility of improving the results by carrying out more accurate calculations based on a refined model of the intercrystalline zone is indicated. R.F.S.Hearmon

539.2

### 4304 ON THE DYNAMICAL THEORY OF DIFFUSION IN CRYSTALS. III. SOME MODEL CALCULATIONS AND RELATION TO CONTINUUM THEORY.

A.W.Lawson, S.A.Rice, R.D.Corneliussen and N.H.Nachtrieb.
J. chem. Phys., Vol. 32, No. 2, 447-55 (Feb., 1960).

For Pt II, see Abstr. 8883 (1959). Some simple models are considered which permit exact evaluation of the various dynamical parameters of the theory of crystal diffusion previously proposed. The models considered suggest that : (a) The jump frequency is insensitive to the normal mode modifications produced by the adjacent vacancy. (b) There is considerable relaxation about a vacancy. (c) The volume of formation of a vacancy is related to the molar volume by $\Delta V^* \cong V/(\gamma_G - \frac{1}{3})$, where $\gamma_G$ is the Gruneisen constant. The restrictions of the models are briefly analysed, and the mass dependence proposed by Bak and Prigogine is compared with the quasi-equilibrium model and the discrepancy discussed.

539.2

### 4305 DYNAMICAL THEORY OF DIFFUSION IN CRYSTALS.

O.P.Manley and S.A.Rice.
Phys. Rev., Vol. 117, No. 3, 632-4 (Feb. 1, 1960).

Corrections to a previous paper (Abstr. 6304 of 1959) are presented. A calculation leading to the simplification of the pair correlation functions is also presented.

539.2

### 4306 MIGRATION BARRIERS FOR CATIONS AND ANIONS IN ALKALI HALIDE CRYSTALS.

R.Guccione, M.P.Tosi and M.Asdente.
J. Phys. Chem. Solids, Vol. 10, No. 2-3, 162-8 (July, 1959).

The Born—Mayer model is applied to the evaluation of the barriers for vacancy migration of cations and anions along the cube face diagonal in NaCl and KCl crystals. The effect of the hardness of the overlap interaction between ions at short distances is quantitatively investigated by using two different forms for the overlap repulsive potential. The values estimated for the energies of motion are compared with the available experimental data and with previous theoretical estimates for NaCl crystals; the hardness of the repulsive potential appears to be an important factor in determining the height of the migration barriers in crystals.

539.22

### 4307 CORRELATION EFFECTS IN IMPURITY DIFFUSION.

J.R.Manning.
Phys. Rev., Vol. 116, No. 4, 819-27 (Nov. 15, 1959).

Expressions are developed giving the correlation factor for an impurity diffusing in an otherwise pure lattice. These expressions will apply in general since, in the derivation, there is no requirement that there must be a large binding energy tending to create vacancy-impurity complexes. When this requirement is eliminated, accurate expressions can be obtained even for the nonclose-packed lattices. Both vacancy and interstitialcy mechanisms are treated. A matrix method developed by LeClaire and Lidiard (Abstr. 8477 of 1956) for the face-centred cubic lattice is applied to various lattices to obtain approximate expressions for the correlation factor. Then a correction is applied giving the effect of those dissociating vacancies (or interstitialcies) which return to the impurity. It is found that the effect is the same as if only a fraction of the dissociative jumps actually occurred. If it is assumed that the effect of an impurity is quite localized, the probability of return can be calculated in a very straightforward manner. It is shown that the effect of returning vacancies (or interstitialcies) can be quite important. The resulting expressions are used to estimate the correlation factor in nondilute alloys.

539.22

### 4308 DIFFUSION OF RADIOACTIVE NOBLE GASES IN URANIUM OXIDES AND URANIUM MONOCARBIDE.

R.Lindner and H.Matzke.
Z. Naturforsch., Vol. 14a, No. 12, 1074-7 (Dec., 1959). In German.

See Abstr. 5418 of 1959. The diffusion as a function of temperature of $Kr^{85}$ in $UO_{2.0}$, $UO_{2.12}$ and $U_3O_8$; of $Rn^{222}$ in $U_3O_8$; and of $Xe^{133}$ in UC, was investigated. The results which are discussed are shown graphically and values for the activation energies are given. S.Weintroub

539.22

### 4309 PERMANENT CHANGE IN LENGTH OF A METALLIC CONDUCTOR AS A RESULT OF ALTERNATING CURRENT ELECTROLYSIS.

H.Wever.
Z. Elektrochem., Vol. 63, No. 8, 921-7 (1959). In German.

A rod-shaped sample of a Sn—Cu alloy was cooled at both ends and an alternating current passed through of sufficient strength to transform the middle of the sample to the γ-phase. After several hours the rod had contracted near the phase boundaries, and later the contraction spread to the whole of the γ-region. An explanation of the effect is given in terms of the creation and diffusion of vacancies. The interpretation suggests that structural vacancies are present in the γ-phase to the extent of 1%, as well as the normal thermal vacancies. B.T.M.Willis

539.22

### 4310 CHANGE OF SOME PROPERTIES OF POLYVINYLCHLORIDE UNDER IONIZING RADIATION.

D.Nachtigall.
Naturwissenschaften, Vol. 46, No. 18, 530 (1959). In German.

The irradiation was carried out in air and in vacuum using X-rays or γ-rays of doses from $10^3$ to $10^6$ r; the viscosity, dielectric properties and breakdown voltages of the two sets of samples were then measured. The viscosity of solutions of the air samples fell with increasing dose up to $10^4$ r and then increased again, attaining the initial value at $10^6$ r; the vacuum samples showed no minimum but a steadily increasing viscosity with dose. The dielectric constant and power factor increased slightly in the frequency range 500 c/s-10 Mc/s. Finally the breakdown voltage was reduced by an order of magnitude for doses exceeding $10^4$ r. B.T.M.Willis

539.2

### 4311 THE SURFACE STRUCTURE OF SILVER CRYSTALS AFTER ARGON-ION BOMBARDMENT.

G.J.Ogilvie.
J. Phys. Chem. Solids, Vol. 10, No. 2-3, 222-8 (July, 1959).

Three single crystals of silver in the form of thin sheets with surfaces parallel to (111), (110) and (100), respectively, have been bombarded with argon ions at several energies in the range 12-4000 eV. Electron-diffraction patterns, taken by transmission and reflection, show short arcs and some streaks not present in the diagrams taken before bombardment. It has been found that after bombardment the surface contains disoriented crystallites. In general, the crystallite orientations are related to the original orientation by tilts about $\langle 112 \rangle$ axes lying in or near the surface of the crystal. It is suggested that the bombarding ions can easily penetrate the lattice if directed parallel to close-packed directions are arrested near dislocation lines giving rise to a high concen-ition of point defects. These in turn give rise to a net current of erstitial atoms diffusing away from the primary dislocation. s net transfer of material is thought to be the cause of the tilting attice blocks.

## ELECTRICAL PROPERTIES OF SOLIDS

(*Superconductivity is included under Low-Temperature Physics*)

539.2 : 537.3

4312 THE ELECTRICAL CONDUCTIVITY OF ANTI-FERROMAGNETIC METALS. Yu.P.Irkhin.
. Metallov i Metallovedenie, Vol. 6, No. 2, 214-21 (1958).
Russian.

The spin ordering can lead to the division of the conduction band o two sub-bands with a forbidden energy gap. Two cases are nsidered: the Fermi level exactly in the middle of the conduction nd and near one edge of it. In the first case, the conductivity can e on semiconducting characteristics, while for the latter there ll be an anomaly in conductivity near the Néel point. The existing perimental data are in qualitative agreement with the theory.

R.Berman

539.2 : 537.3

4313 QUANTITATIVE ASPECTS OF THE CHANGES IN THE ELECTRICAL CONDUCTIVITY OF METALS DUE TO EMISORPTION. P.Zwietering, H.L.T.Koks and C.van Heerden.
Phys. Chem. Solids, Vol. 11, No. 1-2, 18-25 (Sept., 1959).

Measurements of the change in electrical conductivity of aporated metal films caused by chemisorption on the surface are scribed. The quantitative results have made it possible to draw rtain conclusions as to the effective valency of the metal surface oms and the number of bonds formed for each adsorbed molecule. ese conclusions are in agreement with the information obtained om the total number of adsorbed molecules per $cm^2$ of true sur-e area at full coverage. In agreement with the experimental sults of other investigators, a change in bond type for hydrogen iron and nickel at higher coverages is found.

539.2 : 537.3

POSSIBLE EFFECT OF ELECTROMAGNETIC RADIATION ON HE ELECTRICAL CONDUCTIVITY OF ELECTRONIC CONDUCTORS.
e Abstr. 3729

539.2 : 537.3

4314 DETERMINING THE SPECIFIC RESISTANCE OF SOLID AND MOLTEN ALUMINIUM AND ITS ALLOYS. W.Marty.
rown Boveri Rev., Vol. 45, No.11-12, 549-52 (Nov.-Dec., 1958).

When calculating the data of induction furnaces for melting uminium alloys the specific resistance of aluminium and some of s alloys was determined, both in the solid and molten states, and different temperatures. During the process of melting, the esistance increases to double or triple the normal value. The emperature coefficient of the electric resistance is positive in both olid and molten states.

539.2 : 537.3

4315 MEASUREMENTS OF THE HIGH-TEMPERATURE ELECTRICAL RESISTANCE OF ALUMINUM: RESIST-VITY OF LATTICE VACANCIES. R.O.Simmons and R.W.Balluffi.
hys. Rev., Vol. 117, No. 1, 62-8 (Jan. 1, 1960).

The electrical resistance of a 99.995% aluminium wire was easured at temperatures from 14° to 655° C. Values of tempera-ure coefficient of resistance and of resistivity are derived; they iffer somewhat from earlier work. The resistivity values show a rogressive increase above the expected values at high temperatures; his is ascribed to scattering by thermally generated point defects f the type which add atomic sites (vacancy-type defects); the quilibrium concentrations of these have been measured directly n identical material at identical temperatures (Abstr. 4294 of 1960). Three different semi-empirical methods were used to estimate the xpected values of the ideal lattice resistivity in the absence of efects; they gave similar results. The limitations of extrapolation methods are discussed. The resistivity increment ascribed to the acancy-type defects was then obtained by difference and can be represented by

$$\Delta\rho = (4.4 \times 10^{-3}\ \text{ohm cm}) \exp(-0.77\ \text{eV}/kT).$$

The observed formation energy is in close agreement with that obtained by direct concentration measurements and with that obtained in various quenching investigations. This increment is nearly twice the value expected from extrapolation of recent quenching work from the interval 260° to 320° C, however. This relatively small discrepancy can be ascribed to three factors, whose relative importance cannot be precisely evaluated at present. They are (1) failure of quenching techniques to retain all of the equilibrium defect concentrations, (2) the presence of appreciable divacancy concentrations at the highest temperatures, and (3) a contribution to the high temperature resistivity arising from lattice anharmonicity. The increment of about 0.30 μohm cm at the melting point (660° C) corresponds to a resistivity 3 μohm cm/atom % monovacancies in agreement with a crude estimate based upon known effects of solute atoms of different valence.

539.2 : 537.3

4316 MAGNETORESISTANCE EFFECT IN ALUMINIUM-IRON. K.Kuwahara.
J. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 267-80 (Dec., 1958).

The magnetoresistance effect in Al-Fe was studied from the liquid helium temperature up to the Curie temperature with single crystal strips. At high temperatures near the Curie point it was confirmed that the magnetocaloric effect affects the magnetoresistive change in resistance. The amount of magnetocaloric effect estimated from this phenomenon is consistent with that of the direct measurement by Potter. The temperature dependence of the decrease in resistance with applied field above saturation was obtained, and was consistent with the analysis regarding the decrease as being dependent on the change in intrinsic magnetization with temperature and field. The anisotropy coefficients of resistance and magnetoresistance were also determined with the aid of an appropriate amount of specimen current. It was found that they vary in a complicated manner against temperatures and contents of Al, and furthermore confirmed that the resistivity of a domain along an easy direction is smaller when the magnetization vector is parallel to the easy direction than when it is at right angles, at low temperatures in the specimen containing Al above a certain amount.

539.2 : 537.3

4317 MAGNETORESISTANCE OF COPPER. J. de Launay, R.L.Dolecek and R.T.Webber.
J. Phys. Chem. Solids, Vol. 11, No. 1-2, 37-42 (Sept., 1959)

Measured at 297°, 78° and 4.2°K. In a transverse field of 100 kG at room temperature, the resistance increased about $\frac{1}{4}$ per cent and, within experimental error, was a quadratic function of the applied magnetic field. At the lower temperatures the field-dependence of the transverse magnetoresistance is considerably less than quadratic and approaches linearity at high fields. Considerable temperature-dependence for Kohler's rule was found. Saturation of the longitudinal magnetoresistance at high fields was observed at 4.2°K. The change in longitudinal resistance for saturation is of the order of the initial resistance in zero field and was found to be independent of temperature for the range 2.0-4.2°K and of measuring current for the range 0.1-2.0 A. The ratio of the transverse to the longitudinal magnetoresistance of a specimen was found to be a linear function of the applied field. These new features of magnetoresistive behaviour can serve to stimulate the development of an adequate theory of longitudinal and transverse magnetoresistance.

539.2 : 537.3

4318 CALCULATION OF THE RESISTIVITY OF SPHERICAL CAVITIES IN Cu. M.Asdente and J.Friedel.
J. Phys. Chem. Solids, Vol. 11, No. 1-2, 115-19 (Sept., 1959).
In French.

A calculation was made of the resistivity introduced in copper by spherical cavities of different sizes. These voids are represented by square potentials whose height is calculated in order to determine exactly the influence of the screening conduction electrons. The diffusion problem has been completely solved by the partial wave method. The supplementary resistivity increment due to one vacancy exhibits a small maximum for voids composed of two vacancies, and slowly decreases for the larger cavities. This resistivity increment is only decreased by one-half of its initial value for voids containing 100 vacancies. The effective diffusion cross-section is still much smaller, in this case, than the classical cross-section of a hard sphere of the same radius.

539.2 : 537.3

### 4319 HALL COEFFICIENTS OF DILUTE COPPER ALLOYS.

M.D.Blue.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 31-6 (Sept., 1959).

The Hall coefficients of dilute alloys of Mn, Fe, Co, Ni, Zn, Sn, Si and Ge in copper have been measured as a function of composition at room temperature and 77°K with fields up to 10 kG. Two sets of Cu—Mn alloys have been prepared from purified manganese. In one set, special efforts were made to reduce the impurity oxygen content of the manganese. The dependence of the Hall coefficient on composition is different for the two sets, although both have a minimum near 4 per cent manganese. For all these substitutional alloys, the Hall coefficients are independent of magnetic field.

539.2 : 537.3 : 536.48

### 4320 HALL EFFECT, RESISTIVITY AND SUPERCONDUCTIVITY OF SOME METASTABLE URANIUM-RICH ALLOYS.

T.G.Berlincourt.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 12-17 (Sept., 1959).

The Hall effect and electrical resistivity of metastable $\gamma$-phase (b.c.c.) binary alloys of uranium containing 11.6, 21.7 and 30.5 atomic percent molybdenum and 22.2 atomic percent niobium have been studied between ~ 1°K and room temperature in magnetic fields up to 30 kG. The Hall effect coefficients of the latter three alloys were positive and only weakly temperature-dependent, while the Hall coefficient of the 11.6 atomic percent molybdenum alloy was strongly dependent upon both temperature and magnetic field. All samples exhibited superconductivity below ~ 2°K and were characterized by weak negative temperature coefficients of resistivity between the transition temperatures and room temperature. Magnetic fields of ~ 30 kG were required to restore the normal resistivity at 1.2°K. The bearing of the results of this investigation on an understanding of the electronic structure of the $\gamma$-phase is discussed.

539.2 : 537.3

### 4321 ON CONDUCTIVITY MEASUREMENTS IN THE SYSTEM $ZrO_2$—MgO.

E.Kauer, O.E.Klinger and A.Rabenau.

Z. Electrochem., Vol. 63, No. 8, 927-36 (1959). In German.

Following a discussion on the type of conductivity to be expected in $ZrO_2$ containing MgO, measurements on relatively pure $ZrO_2$ containing MgO and other oxides as impurities are reported, covering the temperature range 500-1500°C. These show an abrupt change at the transition from monoclinic to tetragonal structure, accompanied by considerable hysteresis. The conductivity below the transition temperature being nearly independent of the impurity contents, it is deduced that the solubility of MgO in monoclinic $ZrO_2$ is less than 1%. Further measurements on samples containing 20 and 50% MgO are interpreted in terms of the resultant crystal structures, particularly as regards the possibility of freezing-in the high temperature cubic form. K.W.Plessner

539.2 : 537.3

### 4322 ION AND ELECTRON CONDUCTION IN SILVER BROMIDE AND DEVIATIONS FROM THE IDEAL STOICHIOMETRIC COMPOSITION.

C.Wagner.

Z. Elektrochem., Vol. 63, No. 9-10, 1027-30 (1959). In German.

In solid AgBr, the ion conductivity is almost independent of the Ag activity or the Br partial pressure. The electron conductivity is directly proportional to the Ag activity, and the hole conductivity inversely proportional. The conductivities were calculated as functions of the Ag activity at 25° and 277°C. The Ag/Br ratio in AgBr at 277°C can only change between $1 + 10^{-12}$ (for equilibrium with Ag) and $1 - 10^{-7}$ (for equilibrium with Br). The width of the forbidden energy gap is 2.4 eV. J.Franks

539.2 : 537.3

### 4323 ELECTRICAL CONDUCTIVITY OF VITRAIN DURING CARBONIZATION.

M.I.Pope and S.J.Gregg.

Brit. J. appl. Phys., Vol. 10, No. 11, 507-10 (Nov., 1959).

Some vitrain samples, representative of the whole coal range, have been carbonized in oxygen-free nitrogen and their electrical conductivity measured in situ. The results have been interpreted in terms of the known processes occurring during carbonization.

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## Semiconductors

539.2 : 537.311 : 535.37 : 621.315.59 : 621.38

### 4324 SEMICONDUCTORS AND PHOSPHORS [Halbleiter und Phosphore]. [Conference at Garmisch (1956)].

Brunswick : Vieweg (1958), 684 pp.

For abstracts of some of the papers read at the above Conference see Abstr. 9453-4, 9599, 9607, 9616, 9640, 9807, 10218-20, 10635, 10778, 10802-3, 10829, 10851, 10858, 10953-4, 10969-70, 10972, 10975-7, 10983, 10985, 10987, 10992, 10994, 11004, 11018-21, 11025, 11124, 11187, 11545, 11559, 11563, 11621, 12080, 12083-4, 12091, 12101-2, 12116-17, 12125, 12167, 12240-1, 12251-2, 12254-6, 12261, 12269, 12271, 12279-80, 12444, 12563, 12762, 12774, 12788, 12792, 12801, 12813, 13183-4, 13188, 13275, 13296, 13308, 13321, 13365 (1959); 260, 565, 593, 625-6, 655, 1144, 3263 (1960).

539.2 : 537.31

### 4325 ON THE MECHANISM OF DIFFUSION-LIMITED FIELD INSTABILITIES IN SEMICONDUCTORS AT HIGH FIELDS.

H.Rother.

Ann. Phys. (Leipzig), Folge 7, Vol. 5, No. 3-4, 203-10 (1960). In German.

A macroscopic theory is developed to describe the space-charg layers which may be built up in the presence of a sufficiently high electric field. Recombination effects and field emission by defects are considered. There are five basic equations : one describing energy balance, a Poisson equation, and three continuity equations. In view of the large number of parameters, the results are of a semiquantitative nature. P.T.Landsberg

539.2 : 537.311

### 4326 DETERMINATION OF FREE CARRIER LIFETIMES IN SEMICONDUCTORS FROM THE RELAXATION TIME O PHOTO-EXCITED INFRARED ABSORPTION.

L.Huldt.

Ark. Fys., Vol. 15, Paper 19, 229-36 (1959).

An excess concentration of free electrons and holes is generate by light of sufficiently short wavelength. This excess concentration generally decays according to an exponential law governed by the mean lifetime $\tau$. The free carriers absorb infrared radiation. Thus the photoelectric effect is accompanied by an increase in the infrared absorption, the relaxation time of which is identical with the carrier lifetime. By periodically interrupting the exciting radiation, it is possible to determine this relaxation time from infrared transmission measurements. It is shown that such a determination may be performed using arbitrarily slow radiation detectors. Application to hole absorption in germanium confirmed the assumption of a definite lifetime. For hole absorption in silicon, it was not possible to decide the constancy of $\tau$, but its order of magnitude was the sam as had previously been obtained from photoconductive decay measur ments. Improvements and further applications of the method are suggested.

539.2 : 537.31

### 4327 ON THE DEPENDENCE OF THE PARAMETERS OF A SEMICONDUCTOR ON THE DOPE CONCENTRATION.

M.Sh. Giterman and N.P.Kontorovich.

Fiz. Metallov i Metallovedenie, Vol. 7, No. 5, 673-6 (1959). In Russian.

The energy spectrum of a doped n-type semiconductor is invest gated on the basis of the many-electron model of Vonsovskii et al. [ibid Vol. 3, 385 (1956), and Abstr. 7909 (1958)]. The dependence of the activation energy and the effective mass of current carriers on the dope concentration is calculated. The relevant equations are given in full. A.F.Bro

539.2 : 537.311

### 4328 CONCERNING METHODS OF MEASURING THE NERNST EFFECT.

I.V.Mochan and T.V.Smirnova.

Fiz. tverdogo Tela, Vol. 1, No. 7, 1112-14 (July, 1959). In Russian.

A series of observations of the magnitude of the magnetic field for which the Nernst constant becomes zero as a function of temperature in p-type germanium have been made. It was found necessary to make allowance for a Hall potential appearing at the electrodes before the predicted variation (see Abstr. 9188 of 1957) is obeyed. K.N.R.Taylor

539.2 : 537.311

### 4329 CONDUCTIVITY AND VOLTAGE TRANSFER COEFFICIENT OF A SEMICONDUCTOR DIODE IN THE NON-STATIONARY REGIME.

É.I.Adirovich.

tverdogo Tela, Vol. 1, No. 7, 1115-24 (July, 1959). In Russian.
The frequency, phase and transient characteristics are calcu-d for a circuit containing a p-n junction, and the ohmic resi-ce for the case of diffusion capacity predominating. The cri- frequencies and characteristic times are determined. It is vn how the diode parameters, life-time, differential junction stance and ohmic resistance, can be derived graphically from measured frequency for maximum phase lag ($\phi$) and tan $\phi$ at maximum and the low frequency resistance. R.Berman

539.2 : 537.311

### 330 THE DETERMINATION OF THE CAPTURE CROSS-SECTIONS FOR RECOMBINATION AT MULTIPLY-RGED CENTRES.

Yu. A.Kontsevoi.

tverdogo Tela, Vol. 1, No. 8, 1289-93 (Aug., 1959). In Russian.
Expressions for these cross-sections have been obtained. The e of copper in germanium has then been considered using these lts. K.N.R.Taylor

539.2 : 537.311

### 4331 INVESTIGATION OF THE ELECTRICAL PARAMETERS OF SEMICONDUCTORS BY MEANS OF U.H.F. CHNIQUES.

I.I.Gashka and Yu.K.Pozhela.

tverdogo Tela, Vol. 1, No. 9, 1431-3 (Sept., 1959). In Russian.
The lifetime and drift mobility of the current carriers in various iconductors have been measured using u.h.f. methods.
K.N.R.Taylor

539.2 : 537.311

### 4332 ZENER TUNNELING IN SEMICONDUCTORS.

E.O.Kane.

Phys. Chem. Solids, Vol. 12, No. 2, 181-8 (Jan., 1960).
The Zener current in a constant field is calculated both with without the Wannier—Adams reduction of the interband-coupling ms. The Zener current is only slightly different in the two cases, act which has already been noted by Wannier. The apparent re-ction of interband coupling is interpreted as a polarization correc-n. A detailed calculation of the Zener current is made for a mple two-band model which is applicable to InSb. The evaluation the tunneling integral follows closely a calculation due to Keldysh bstr. 4964 of 1958).

539.2 : 537.311

### 4333 LONGITUDINAL HALL EFFECT.

L.Grabner.

ys. Rev., Vol. 117, No. 3, 689-97 (Feb. 1, 1960).
The "Hall Field" is defined as the electric field which is an odd ction of the magnetic field. Because of the Onsager relations it is rpendicular to the current. It is split into the conventional trans-rse Hall field (TH-field) in the direction of B × I and a longitud-l Hall field (LH-field) in the direction of I × ( B × I). Some prop-ties of the LH-field contrast with those of the TH-field. In part-lar, it vanishes (a) at saturation, (b) for spherical energy surfaces, d (c) when the magnetic field is parallel to an axis of rotation of e crystal. Its dependence on carrier concentration is the same as t of the TH-field; its sign, however, is determined by band struc-re as well as carrier sign. For a system consisting of n-type rmanium the properties of the LH-field are investigated theoreti-lly and experimentally.

539.2 : 537.311

### 4334 ELECTRIC CONDUCTION IN SEMICONDUCTORS.

H.Fröhlich and G.L.Sewell.

roc. Phys. Soc., Vol. 74, Pt 5, 643-7 (Nov., 1959).
The note surveys various modes of conduction in semiconductors en the mobility is low, as it is in many oxides. P.T.Landsberg

539.2 : 537.311

### 4335 THE INFLUENCE OF INTERELECTRONIC COLLISION ON CONDUCTION IN NON-POLAR CRYSTALS.

.Uchiyama.

rogr. theor. Phys., Vol. 21, No. 6, 938-9 (June, 1959).
A formula is derived for the low-field mobility on the basis of ratton's method (Abstract 5872 of 1958). The temperature varia-on of the mobility of carriers in Si and Ge is briefly discussed on e light of this result. L.Pincherle

539.2 : 537.311

### 4336 HALL EFFECT IN SEMICONDUCTORS WITH P-N TRANSITIONS.

O.Madelung.

Z. Naturforsch., Vol. 14a, No. 11, 951-8 (Nov., 1959). In German.
The theory of the Hall effect is generalised to the case when p—n transitions occur at right angles to the direction of the Lorentz force. The possibility of applying the theory to the two changes in sign of the Hall effect in p-type In As is considered.
P.T.Landsberg

539.2 : 537.311

### 4337 CARRIER RECOMBINATION IN SEMICONDUCTORS AFTER HIGH EXCITATION.

M.Zerbst, G.Winstel and W.Heywang.

Z. Naturforsch., Vol. 14a, No. 11, 958-62 (Nov., 1959). In German.
Developments of the Shockley—Read theory of recombination for high excitation, assuming a small density of recombination centres. Consideration is given to some situations which can occur in the case of silicon and germanium. P.T.Landsberg

539.2 : 537.311 : 539.213

GLASS-LIKE SEMICONDUCTORS. See Abstr. 3263.

539.2 : 537.311

### 4338 INFLUENCE OF FAST NEUTRONS ON THE RECOMBINATION OF ELECTRON—HOLE PAIRS IN GERMANIUM.

Nguyen Van Dong and A.Barraud.

C. R. Acad. Sci. (Paris), Vol. 249, No. 21, 2181-3 (Nov. 23, 1959). In French.
The positions of the recombination levels and the capture probabilities of holes and electrons in n-and p-type germanium were determined from resistivity—temperature measurements taken after fast neutron bombardment. B.T.M.Willis

539.2 : 537.311

### 4339 THE DETERMINATION OF THE NUMBER OF ACCEPTOR LEVELS OF DEFECTS PRODUCED IN GERMANIUM BY THE ACTION OF $\gamma$-RAYS.

N.A.Bitovskii, T.V.Mashovets and S.M.Ryvkin.

Fiz. tverdogo Tela, Vol. 1, No. 9, 1381-4 (Sept., 1959). In Russian.
Four acceptor levels have been found to be associated with a single defect caused by $\gamma$-rays from $Co^{60}$. The depth of the upper level below the conduction band is 0.18 eV and the defect cross-section $4 \times 10^{-27}$ $cm^2$. K.N.R.Taylor

539.2 : 537.311

### 4340 DISLOCATION ACCEPTOR LEVELS IN GERMANIUM.

R.K.Mueller.

J. appl. Phys., Vol. 30, No. 12, 2015-16 (Dec., 1959).
Acceptor levels in gernamium due to the presence of dislocations can be discussed in terms of several models. The author assumes that the electrons in the closely spaced dangling bonds interact to form a narrow band of electron states along the dislocations. A position of the acceptor levels found from capacitance and conductance measurements on small angle grain boundaries is used to derive an expression for carrier depletion as a function of temperature, which it is suggested is in better agreement with experimental results than a rather similar relation derived from a model envisaging single,non-interacting acceptor sites describing the dangling bonds. I.Cooke

539.2 : 537.311

### 4341 BARRIER TEMPERATURE AT TURNOVER IN GERMANIUM P—N JUNCTION.

J.Yamaguchi and Y.Hamakawa.

J. Phys. Soc. Japan, Vol. 14, No. 2, 232-3 (Feb., 1959).
The ambient temperature of grown germanium p—n junctions is deduced from the reverse current at turnover and of point-contact diode junctions by a method previously reported (see Abstr. 12277 of 1959). From the results it is concluded that grown p—n junctions are patchy and that breakdown occurs when the intrinsic temperature is reached at any one spot in the junction. C.A.Hogarth

539.2 : 537.311

### 4342 CHANGE OF SURFACE RECOMBINATION VELOCITY OF GERMANIUM BY $\gamma$-RAY IRRADIATION.

K.Komatsubara.

J. Phys. Soc. Japan, Vol. 14, No. 3, 383-4 (March, 1959).
The surface recombination velocity s decreases initially with

irradiation, reaching a minimum after a dose of 2 × $10^7$ rontgens. Subsequent doses increase s. An explanation is given in terms of changes in surface conductivity. C.Hilsum

539.2 : 537.311

### 4343 ANNEALING OF ELECTRON IRRADIATED GERMANIUM.

G.Airoldi, Z.Fuhrman and E.Germagnoli.

Nuovo Cimento, Vol. 14, No. 2, 452-3 (Oct. 16, 1959).

Crystals of n-type Ge, with initial resistivities between 0.01 and 1 ohm cm, were irradiated with 1.3 MeV electrons. The results support the theory of annealing kinetics which takes into account both the preferential recombination of close interstitial-vacancy pairs and recombination controlled by thermally induced diffusion of mobile defects. A migration energy of 1.4 eV is deduced for the latter. D.J.Huntley

539.2 : 537.311

### 4344 PROPERTIES OF CLEANED GERMANIUM SURFACES.

R.Forman.

Phys. Rev., Vol. 117, No. 3, 698-704 (Feb. 1, 1960).

Field effect and conductivity measurements were made on cleaned (111) and (100) germanium surfaces. The surfaces were cleaned by an argon bombardment technique similar to that developed by Farnsworth. The cleaned surfaces were exposed to a modified Brattain—Bardeen ambient cycle (Abstr. 1637 of 1953) and the change in surface properties measured. The cleaned surface data showed that a (100) surface is more highly p-type than a (111) surface, and these results are interpreted qualitatively by an atomistic model.

539.2 : 537.311

### 4345 RECOMBINATION RELAXATION EFFECTS IN GERMANIUM SURFACES.

D.H.Lindley and P.C.Banbury.

Proc. Phys. Soc., Vol. 74, Pt 4, 395-400 (Oct. 1, 1959).

The conductance of a thin single-crystal slab of germanium has been modulated by a small electric field of variable frequency, capacitively applied to the large face. The resulting dispersion which is related to the generation and recombination of minority carriers at the surface has been studied as a function of surface potential by using different ambient gases. The results show some agreement with the single-energy-level model analysed by Garrett (Abstr.2302 of 1957) and indicate in addition that the etched surfaces investigated were non-uniform.

539.2 : 537.311

### 4346 THE FIELD-DEPENDENCE OF CARRIER MOBILITY IN SILICON AND GERMANIUM.

A.C.Prior.

J. Phys. Chem. Solids, Vol. 12, No. 2, 175-80 (Jan., 1960).

The variation of mobility with electric field was measured for n- and p-type silicon and germanium with fields up to $10^5$ V/cm. For p-type silicon the variation is found to depend on hole concentration. For the other materials any variation with concentration must be smaller, and these experiments are inconclusive as to its existence.

539.2 : 537.311

### 4347 GERMANIUM—SILICON ALLOY JUNCTIONS.

Y.Matukura.

J. Phys. Soc. Japan, Vol. 14, No. 3, 374 (March, 1959).

A p—n junction was made by alloying gallium-doped germanium on to arsenic-doped silicon. The energy-gap in the region of the junction depends on the alloying temperature and the initial impurity concentrations. The results were in good agreement with the theory. C.Hilsum

539.2 : 537.311

### 4348 IMPACT IONIZATION OF IMPURITIES IN SILICON AT LOW TEMPERATURES.

J.C.Sohm.

C.R. Acad. Sci. (Paris), Vol. 249, No. 25, 2737-9 (Dec. 21, 1959). In French.

Summary of experimental results concerning ionization effects in silicon crystals showing significant impurity compensation, at liquid hydrogen temperatures. The avalanche field is found to be sensitive to the degree of impurity compensation. C.A.Hogarth

539.2 : 537.311

### 4349 ELECTRICAL PROPERTIES OF HIGH-PURITY SILICON MADE FROM SILICON TETRAIODIDE.

L.V.McCarty.

J. Electrochem. Soc., Vol. 106, No. 12, 1036-42 (Dec., 1959).

Resistivities, type of conduction, and lifetimes of minority carriers of single crystals of iodide silicon are recorded as a func tion of the purification procedure for silicon tetraiodide. Samples silicon were prepared by decomposition of silicon tetraiodide on ho tantalum and hot quartz surfaces in vacuum. Distillation in a 12 pl quartz column of silicon tetraiodide prepared from 99.7% silicon re sults in single crystals of silicon that are uniformly n-type with maximum resistivities at the seed end in the range 0.3-1 ohm cm. Two recrystallizations from solvents before the distillation step re sult in both p- and n-type crystals with, respectively, 150-650 ohm and 75-170 ohm cm resistivity ranges at the seed ends. Distillation of silicon tetraiodide is particularly effective in removing boron, while recrystallization and zone melting are effective for removing group V impurity iodides.

539.2 : 537.31

### 4350 ELECTRON CAPTURE BY A LATTICE VACANCY IN S

A.Morita.

Phys. Rev., Vol. 117, No. 1, 84-9 (Jan. 1, 1960).

The electron-capture cross-section of the deep trap due to a lattice vacancy in Si is calculated by taking into account the distort of the lattice vibrations by the lattice vacancy. It is assumed that the trap is a neutral centre for electron capture. The results show that although the distortion effect enlarges the calculated cross-section by three orders of magnitude at 300° K, it is not enough to explain the magnitudes of observed cross-sections.

539.2 : 537.31

### 4351 RARE EARTH COMPOUND SEMICONDUCTORS.

J.F.Miller, F.J.Reid and R.C.Himes.

J. Electrochem. Soc., Vol. 106, No. 12, 1043-6 (Dec., 1959).

Selenides of La, Er, and Y, and tellurides of La, Er, Gd, and Y were prepared by direct reaction of the elements. Measured electrical characteristics indicate semiconducting behaviour, with the possibility that a wide range of properties can be obtained within these series of rare earth compounds. Observed room-temperatur resistivities, for example, ranged from about $10^{-4}$ ohm cm for $La_2Te_3$ and ErSe to the insulator range for $Y_2Se_3$. All the compoun prepared possess high melting points (1400°-2000° C) and exhibit g thermal stability. The dissociation pressure of $Gd_2Te_3$ at its melti point appears to be as low as 0.01 atm.

539.2 : 537.31

### 4352 SOME SEMICONDUCTIVE PROPERTIES OF DILUTE BINARY SOLID SOLUTIONS OF BISMUTH IN TELLURIUM AND TELLURIUM IN BISMUTH.

T.R.Piwkowski.

Nature (London), Vol. 184, 355-6 (Aug. 1, 1959).

Melts of Bi containing up to 10% Te, and Te containing up to 10% Bi were prepared, and the conductivity and thermoelectric power measured on samples taken from them. The Bi samples wer all n-type, and the Te samples all p-type. Evaporated films about 1 μ thick were made from these materials and their electrical and photoelectric properties were assessed. It is suggested that dilute binary solutions of bismuth and tellurium are semiconductors. C.Hilsu

539.2 : 537.311 : 53

### 4353 OPTICAL AND ELECTRICAL PROPERTIES OF BISMUTH TELLURIDE $Bi_2Te_3$.

J.Lagrenaudie.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 39A-40A (March, 1957). In French.

$Bi_2Te_3$ has a gap 0.19 eV and a refractive index about 8 at room temperature. It is strongly analagous to PbTe, in spite of their structural differences. The type can be reversed by compression a room temperature.

539.2 : 537.31

### 4354 CRYSTAL POTENTIA AND ENERGY BANDS OF SEMICONDUCTORS. II. SELF-CONSISTENT CALCULATIONS FOR CUBIC BORON NITRIDE.

L.Kleinman and J.C.Phillips.

Phys. Rev., Vol. 117, No. 2, 460-4 (Jan. 15, 1960).

For Pt I, see Abstr. 1629 (1960). A self-consistent crystal potential is constructed for cubic BN. Exchange is included accord to the Slater free-electron approximation. The effect of the heteropolar character of the potential is included explicitly in an approximately self-consistent treatment of the valence-electron charge density. The energy gap is found to be about twice that of diamond, consistent with the results of other zincblende crystals and their diamond-type analogues. The maximum of valence band and the imum in the conduction band are at the centre and (100) face of Brillouin zone, respectively. It is suggested that the hetero- r potential splits the valence band into two sub-bands. The er sub-band width is about 5 eV, while the higher (which contain e times as many states) has a band width of about 4 eV. The rgy gap between the sub-bands is about 10 eV. The effect should ommon to all zincblende crystals and may be observable by X-ray emission.

539.2 : 537.311

4355 ELECTRICAL RESISTIVITY OF BORON-PHOSPHORUS ALLOYS. E.S.Greiner and J.A.Gutowski.

ppl. Phys., Vol. 30, No. 11, 1842-3 (Nov., 1959).

Polycrystalline specimens of boron containing up to 0.08 at. % sphorus and one alloy B—P (86% - 14%) were prepared by uction of boron trichloride and phosphorus trichloride on a hot talum filament. The specimens containing small amounts of sphorus had a rhombohedral structure, but the structure of the er alloy was different, and could not be identified. Measurements esistivity were made over a temperature range of -160 to 700°C. osphorus addition decreased the resistivity at temperatures below °K. The resistivity of the sample containing 14% phosphorus was nificantly higher in the intrinsic range and lower in the extrinsic ge than that of the other alloys. All materials were p-type.

C.Hilsum

539.2 : 537.311

4356 HOLE CONDUCTION AND PHOTOVOLTAIC EFFECTS IN CdS. J.Woods and J.A.Champion.

Electronics and Control, Vol. 7, No. 3, 243-53 (Sept., 1959).

Semiconducting crystals of CdS have been prepared in which conduction current is carried preponderantly by positive holes. is is indicated by the positive sign of the Hall voltage and the rmoelectric power. The preparation of these crystals, which re heavily doped with 1-2% Cu, is described. Measurements of ctrical conductivity, Hall coefficient and thermoelectric power er the temperature range 95-380°K are reported. The results e difficult to interpret, but suggest that conduction occurs via purity levels due to copper. Similar measurements on some ical n-type semiconducting CdS crystals are reported for mparison purposes. Some attempts have been made to prepare n junctions in CdS. Appreciable photovoltaic effects have been nd, and the spectral response and rectification characteristics n be explained in terms of a p—n junction model.

539.2 : 537.311

4357 ELECTRICAL RESISTIVITY CHANGES OBSERVED IN A SEMICONDUCTING DIAMOND AFTER HEAT EATMENT. R.E.Mutch and F.A.Raal.

ture (London), Vol. 184, 1857-8 (Dec. 12, 1959).

A description is given of some studies on the effect of heat eatment on a unique semiconducting diamond. This diamond has a ue portion and a white portion with a sharp boundary. Resistance nheated) of the blue portion was 97.8 ohm cm and of the white rtion 20 500 ohm cm. After heating to temperatures up to 1400°C sistance of the blue portion was 56.5 ohm cm, and of the white rtion 330 ohm cm. The considerable reduction of the white portion discussed in terms of donors and acceptors.

S.Tolansky

539.2 : 537.311

4358 ELECTRICAL PROPERTIES OF POLY-COPPER PHTHALOCYANINE. A.Epstein and B.S.Wildi.

chem. Phys., Vol. 32, No. 2, 324-9 (Feb., 1960).

Hall effect and electrical resistivity measurements as a function temperature to ~450°C were carried out on a polymer of copper hthalocyanine. From the Hall effect data it is concluded that intrin- cally the polymer of copper phthalocyanine is P type. Two states this polymer have been determined, one has an activation energy 0.26 ev and a carrier density $\sim 10^{16}/cm^3$ (the carrier concentration arying with temperature), a second, a heat-treated polymer, also hows P type conductivity but the carrier density is $\sim 10^{18}/cm^3$ and is onstant in the range of temperature measured. The mobility in the eat-treated polymer is found to increase with increasing tempera- ure. N type conductivity observed on the first structure is believed be a consequence of impurities.

539.2 : 537.311

4359 SOME RESULTS ON THE DIFFUSION AND THE EFFECT OF IMPURITIES ON THE ELECTRICAL PROPERTIES F GALLIUM ANTIMONIDE. B.I.Boltaks and Yu.A.Gutorov.

iz. tverdogo Tela, Vol. 1, No. 7, 1015-21 (July, 1959). In Russian.

Experimental data on the effect of In, Sb, Se and Te on the electrical properties of GaSb are reported over a temperature range from −120°C to 680°C. The diffusion of these elements (and also Sn) in diffusion annealed specimens was also examined. The results indicate that there is a definite correlation between the diffusion activation energy of these impurities and their effect on the electrical properties of the material.

K.N.R.Taylor

539.2 : 537.311

4360 THE REVERSE CHARACTERISTICS OF GALLIUM ARSENIDE P—N JUNCTIONS. J.W.Allen.

J. Electronics and Control, Vol. 7, No. 3, 254-60 (Sept., 1959).

A method of making p—n junctions in GaAs by diffusion of zinc is described. On the basis of their reverse characteristics the junctions can be divided into two groups. "Hard" junctions have a sharp breakdown, their breakdown voltage increases with increasing temperature and their capacity varies as the inverse cube root of the bias voltage. "Soft" junctions do not show a rapid change of slope in their current—voltage curve, their voltage at a given current decreases with increasing temperature and their capacity—voltage characteristic is anomalous.

539.2 : 537.311

4361 THE ENERGY-DEPENDENCE OF ELECTRON MASS IN INDIUM ANTIMONIDE DETERMINED FROM MEASUREMENTS OF THE INFRARED FARADAY EFFECT.

S.D.Smith, T.S.Moss and K.W.Taylor.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 131-9 (Sept., 1959).

Measurements of Faraday rotation due to free electrons have been used to deduce values of dE/dk as a function of $k_F$ for the conduction band of InSb. An E/k curve is obtained by numerical integration to a height of 0.15 eV from the bottom of the band. The results show excellent agreement with the band shape calculated by Kane by the $k \cdot p$ perturbation. A value of $m_0^*$, the mass at k = 0, is found from the slope of dE/dk at k = 0, the average value obtained being 0.0143 $m_0$. The rotation due to free electron is found to have an opposite sense to that associated with interband transitions.

539.2 : 537.311

4362 PIEZORESISTANCE IN n-TYPE InP. A.Sagar.

Phys. Rev., Vol. 117, No. 1, 101 (Jan. 1, 1960).

Piezoresistance measurements were made at 77° and 330°K. The results suggest a spherical energy band for this material.

539.2 : 537.311

4363 SURFACE LAYER GRANULAR STRUCTURES IN IRON OXIDE CERAMICS. J.Suchet.

J. Phys. Radium, Vol. 18, Suppl. No. 3, 10A-18A (March, 1957). In French.

A model of the surface layer of a semiconducting ceramic was used to study the semiconductor obtained by valency induction of $TiO_2$ on the hematite and to study a mixed Mn—Zn ferrite. The dispersion of the resistivity and the permittivity as a function of the frequency; the variation of their values as well as those of the permeability as a function of the sintering temperature, and the nature of the atmosphere and the concentration of the ferrous ions are interpreted in terms of two possible stages of superficial oxidation during the cooling. The same interpretation is given for the phenomenon of the reversible ageing of the permeability for the Mn—Zn ferrite (disaccommodation) reported by Snoek [New developments in ferromagnetic materials. Amsterdam: Elsevier (1949)]. The advantage of adding cuprous ions is explained. Several hypotheses on the physical structure of matter in the intergranular boundaries are given.

539.2 : 537.311

4364 SEMICONDUCTING BEHAVIOUR OF DIOXIDES OF MANGANESE WITH FOREIGN ION ADDITIVES, AS A FUNCTION OF THE MEASURING FREQUENCY.

J.P.Chevillot and J.Brenet.

C.R. Acad. Sci. (Paris), Vol. 249, No. 19, 1869-71 (Nov. 9, 1959). In French.

The resistivity of specimens of $\beta$-$MnO_2$ with $Li^+$ additives in the range of $\tau$ = 0.01, 0.004, and 0.001 (where $\tau$ is ratio of $Li^+$ ion concentration to that of Mn atoms) was measured as functions of frequency (300-15 000 c/s) and temperature (25°, 40° and 60°C). The resistivity increases with frequency and the effect is more marked for high $\tau$ and low temperature. For pure $\beta$-$MnO_2$ there is no frequency variation.

C.A.Hogarth

539.2 : 537.311

4365 SEMICONDUCTING SILICON CARBIDE.
H.K.Henisch.
Nature (London), Vol. 184, 158-9 (July 18, 1959).

A short account of the conference held at Boston in April 1959, which includes brief notes on crystal growth, electrical properties and applications. . C.Hilsum

539.2 : 537.311

4366 VANADIUM SPINELS AS VALENCY SEMICONDUCTORS.
B.Reuter, J.Jaskowsky and E.Riedel.
Z. Elektrochem., Vol. 63, No. 8, 937-43 (1959). In German.

Sintered specimens in the series $MgV_2O_4-Mg_2VO_4$ and in the series $CoV_2O_4-Co_2VO_4$ were prepared and their conductivity measured over a range of temperatures. All compositions crystallized in the spinel structure, the valency of the V ions being 3 and 4 at the extremes of the solid solution series. As expected from the coexistence of $V^{3+}$ and $V^{4+}$ ions in the same lattice, pronounced conductivity is found in the mixed crystals, passing through a maximum as a function of composition in the case of the Mg series, but not in the Co series. It is thought that the Co ion can also change its valency and so provide conduction electrons. Activation energies for the conduction process are derived. K.W.Plessner

## Photoconductivity

539.2 : 537.312

4367 CALCULATION OF RELAXATION PROCESSES OF A PHOTOTRIODE AT SMALL ILLUMINATION INTENSITIES. N.D.Potekhina.
Fiz. tverdovo Tela, Vol. 1, No. 10, 1509-15 (Oct., 1959). In Russian.

Shockley's theory is used to calculate transient changes of current and emitter-base potential due to the switching on or off of illumination on the base of a p—n—p diode (base floating). The dependence of the damping coefficient on the intensity of the absorbed light and the ratio of the conductivities of emitter and base was found. D.J.Huntley

539.2 : 537.312

4368 THEORY AND APPLICATION OF THERMALLY STIMULATED CURRENTS IN PHOTOCONDUCTORS.
R.R.Haering and E.N.Adams.
Phys. Rev., Vol. 117, No. 2, 451-4 (Jan. 15, 1960).

The theory of thermally stimulated currents is investigated in the limits of slow and fast retrapping. A method of obtaining the ionization energy E of the relevant traps is discussed. This method depends on the shift of the conductivity maxima with heating rate and does not involve prior knowlege of the trapping cross-sections or of the heating rate.

539.2 : 537.312

4369 FLUCTUATIONS IN CdS DUE TO SHALLOW TRAPS.
J.J.Brophy and R.J.Robinson.
Phys. Rev., Vol. 117, No. 3, 738-9 (Feb. 1, 1960).

The observed current noise of a lightly doped cadmium sulphide single crystal under uniform illumination is quantitatively explained by application of the generation—recombination theorem of retrapping effects. The results yield a frequency factor of $10^9$ $sec^{-1}$ for a discrete set of traps located 0.4 eV below the conduction band and $10^8$ $sec^{-1}$ for traps distributed between 0.3 and 0.5 eV. When the quasi-Fermi level is near the discrete states, the current noise spectra show a relaxation component characteristic of generation and recombination involving these levels.

539.2 : 537.312

4370 PROPERTIES OF P-TYPE INDIUM ANTIMONIDE. II. PHOTOELECTRIC PROPERTIES AND CARRIER LIFETIME. C.Hilsum.
Proc. Phys. Soc., Vol. 74, Pt 1, 81-6 (July 1, 1959).

Photoconductive and photoelectromagnetic effects were studied on p-type specimens of InSb with impurity concentrations varying from $10^{15}$ to $2 \times 10^{17}$ $cm^{-3}$. Results were consistent with a simple theory, which assumes that the carrier relaxation time is independent of energy. Values for carrier lifetime were deduced. The fall in lifetime with increasing impurity concentration is explained as the result of two recombination processes, radiative recombination and recombination via traps.

539.2 : 537.3

4371 POSITIVE HOLE INJECTION INTO ORGANIC CRYSTA
H.Kallmann and M.Pope.
J. chem. Phys., Vol. 32, No. 1, 300-1 (Jan., 1960).

Measurements were made of dark currents and photocurrents in single crystals of anthracene. The electrodes were solutions containing 1 M NaI with and without $I_2$. In the presence of $I_2$, positi holes are injected into the anthracene.

539.2 : 537.3

4372 PHOTOELECTRIC CONDUCTIVITY FOR INORGANIC COMPLEX COMPOUNDS. H.Schindler.
Z. angew. Phys., Vol. 12, No. 1, 33-8 (Jan., 1960). In German.

It is suggested that in this type of material the empirical rule that photoconductivity only occurs for refractive indices in excess of 2 should be replaced by a refractive index of 1.6. Measuremen were made on $K_3Fe(CN)_6$, $K_4Fe(CN)_6$, $K_3Mn(CN)_5NO$, $K_2Ni(CN)_4$ and i included temperature variation and Hall effect observations.
J.Houg

## Thermoelectric Properties

539.2 : 537.

4373 THERMOELECTRIC EFFECTS IN COPPER—GOLD ALLOYS. M.D.Blue.
Phys. Rev., Vol. 117, No. 1, 134-8 (Jan. 1, 1960).

Measurements of the resistivity and thermoelectric power of t binary alloy CuAu and of CuAu alloys containing dilute amounts of Ni are analysed using the thermoelectric power formula of Mott. At the transition temperature, anomalies in the thermoelectric power are observed. The scattering cross-section and its derivative with respect to energy for Ni in CuAu are determined. The results are similar in value to these same parameters measured for dilute amounts of Ni in Cu.

539.2 : 537.32 : 621.362 : 621.315.

4374 THE THERMOELECTRIC FIGURE OF MERIT AND IT RELATION TO THERMOELECTRIC GENERATORS.
R.P.Chasmar and R.Stratton.
J. Electronics and Control, Vol. 7, No. 1, 52-72 (July, 1959).

The expression for the figure of merit of a semiconductor of given carrier mobility and lattice thermal conductivity expressed i terms of generalized Fermi—Dirac functions has been numerically evaluated for various scattering indices. The results are presente graphically enabling the maximum figure of merit to be found. Hig temperature limitations due to minority carrier production are con sidered in relation to the energy gap of the semiconductor. The results are discussed in connection with bismuth telluride and othe sulphides, selenides and tellurides of the heavy metals.

537.32 : 539

FIGURE OF MERIT OF THERMOELECTRIC GENERATORS.
See Abstr. 4374-5

539.2 : 537.32 : 621.362 : 621.315.

4375 THE FIGURE OF MERIT OF A THERMOELECTRIC GENERATOR. R.Stratton.
J. Electronics and Control, Vol. 7, No. 1, 73-6 (July, 1959).

Optimum conditions are deduced for a thermoelectric generator or refrigerator with n- and p-type semiconducting branches which have different physical parameters. The results are relatec in a simple manner to the previously calculated optimum condition for the individual figure of merit of a single substance.

539.2 : 537.32 : 536

THERMODYNAMIC PROPERTIES OF THE THERMOCOUPLE
See Abstr. 3693

539.2 : 537.

EFFICIENCY OF THERMOELECTRIC DEVICES. See
Abstr. 3732-4

## lectric Properties

539.2 : 537.2

HIGH-FREQUENCY METHODS OF MEASURING DIELECTRIC OPERTIES OF SOLIDS. See Abstr. 3717-18

539.2 : 537.2 : 621.315.612

4376 SILICON NITRIDE THIN FILM DIELECTRIC.
C.R.Barnes and C.R.Geesner.
Electrochem. Soc., Vol. 107, 98-100 (Feb., 1960).

Thin adherent nonporous films of pure silicon nitride were osited from the vapour phase on hot molybdenum substrates by olytic deposition. Such films, when incorporated between moly- num plates to form capacitors, were found to maintain satis- tory dielectric properties up to and above 600°C. Silicon nitride tings, deposited by the method described, also offer a convenient l effective method of encapsulation for protecting metal surfaces m atmospheric oxidation up to and above 1000°C.

539.2 : 537.2 : 537.533 : 621.385.032.213.13

ALUNDUM-COATED VALVE-HEATERS. LEAKAGE CURRENT ARACTERISTICS. See Abstr. 3796

539.2 : 537.2 : 535.51

4377 OPTICAL AND DIELECTRIC STUDY OF BORACITE.
Y.Le Corre.
Phys. Radium, Vol. 18, No. 11, 629-31 (Nov., 1957). In French.

Boracite, $Mg_3B_7O_{13}Cl$, seems to be a ferroelectric ; its do- ins are sensitive to the application of an electric field; the di- ctric constant shows a sudden discontinuity at 265°C; the hystere- cycle is visible, just below the transition. The impurities of the neral may explain the observed weak remanent polarization 002 $\mu C/cm^2$).

539.2 : 537.2

4378 DIELECTRIC PROPERTIES OF A SINGLE CRYSTAL OF PARTIALLY DEUTERATED GLYCOCOL [GLYCINE] LPHATE. J.Chapelle and L.Taurel.
R.Acad. Sci. (Paris), Vol. 249, No. 15, 1332-3 (Oct. 12, 1959). French.

An 85% deuterated single crystal of glycocol sulphate was udied. It has a transition point at 57.9°C, above which the di- ectric constant obeys a Curie law, and below which the crystal is rroelectric with a maximum spontaneous polarization of $30 \times 10^{-7}$ ulomb/cm². The polarization is incomplete unless the crystal is rst heated above the transition temperature. J.B.Birks

539.2 : 537.2

4379 EFFECT OF HYDROSTATIC PRESSURE ON THE FERROELECTRIC PROPERTIES OF TRI-GLYCINE ULFATE AND SELENATE. F.Jona and G.Shirane.
hys. Rev., Vol. 117, No. 1, 139-42 (Jan. 1, 1960).

The transition temperatures $T_C$ of triglycine sulphate and somorphous triglycine selenate are raised by the application of ydrostatic pressure. Up to 2700 atm, the dependence of $T_C$ on ressure is linear with a slope of $2.6 \times 10^{-3}$ degrees/atm for the ulphate and $3.8 \times 10^{-3}$ degrees/atm for the selenate. The Curie—Weiss law, $\epsilon_b \cong C/(T - T_C)$, is unaffected by pressure except for he shift in transition temperature. The curve of the spontaneous olarization is shifted accordingly along the temperature axis; in he vicinity of the transition point, the square of the spontaneous olarization depends linearly on temperature and pressure. The esults are discussed in terms of the thermodynamic theory of erroelectrics.

539.2 : 537.2

4380 FERROELECTRIC PROPERTIES OF MIXED CRYSTALS OF TRIGLYCINE SULFATE/SELENATE.
E.Fatuzzo and R.Nitsche.
Z. Elektrochem., Vol. 63, No. 8, 970-1 (1959).

The Curie point, derived from the spontaneous polarization falling to zero, is plotted over the whole of the composition range. The permittivity having also been measured, two of the coefficients in Devonshire's free energy expansion are calculated. They are roughly constant for all the mixed crystals. K.W.Plessner

539.2 : 537.2

4381 THE PROPERTIES OF BARIUM TITANATES OF NEARLY STOICHIOMETRIC COMPOSITION.
G.Lapluye, G.Morinet and P.Palla.
C.R. Acad. Sci. (Paris), Vol. 249, No. 21, 2172-4 (Nov. 23, 1959). In French.

Measurements have been made on ceramic $BaTiO_3$ prepared from spectroscopically pure $BaCO_3$ and $TiO_2$ by a standardized procedure to determine the effects of departures from stoichiometric composition of up to ± 4 mole %. The dielectric constant at 20°C, and the remanent polarization are a maximum for the stoichiometric composition. Tan δ, its variation with frequency and the hysteresis losses are reduced for compositions with excess $TiO_2$.

L.E.Cross

539.2 : 537.2

4382 IRREVERSIBLE MOTIONS OF A 90° DOMAIN IN $BaTiO_3$. J.Fousek and B.Březina.
Czech. J. Phys., Vol. 9, No. 2, 265-6 (1959).

Motion in a 50 c/s electric field of a c-domain was studied. The dependence of the deflection upon the instantaneous field shows hysteresis, and saturation occurs at 4.1 µ deflection. Factors affecting irreversible wall motion are enumerated. The wall movements coincide with the peaks in the current through the crystal and therefore contribute to the hysteresis dependence of the total polarization on voltage. R.C.Kell

539.2 : 537.2

4383 ANTI-PARALLEL FERROELECTRIC DOMAINS IN SURFACE SPACE-CHARGE LAYERS OF $BaTiO_3$.
V.Janovec.
Czech. J. Phys., Vol. 9, No. 4, 468-80 (1959).

It is shown on simplified models of a surface space-charge layer of a single crystal of $BaTiO_3$ that in the surface region, in which the direction of the electric field is opposite to the direction of spontaneous polarization inside the crystal, anti-parallel domains can exist. The dimensions of these domains are determined. The use of the results obtained is proposed for interpreting the micro-relief of the etch figures and for explaining the different phases of the polarization reversal process of a single-domain single crystal of $BaTiO_3$.

539.2 : 537.2

4384 RADIATION-INDUCED CHANGES IN THE FERROELECTRIC PROPERTIES OF SOME BARIUM TITANATE-TYPE MATERIALS. I.Lefkowitz.
J. Phys. Chem. Solids, Vol. 10, No. 2-3, 169-73 (July, 1959).

Measurements of ceramic $BaTiO_3$ dielectric constant versus temperature as a function of pile irradiation showed modification of the Curie-point transition. In the case of commercially pure ceramic $BaTiO_3$ there was a depression of the dielectric-constant peak with little modification of the room-temperature dielectric constant. Ceramics made with the additives showed a shift of the Curie point as well as a depression of the dielectric-constant peak. Material that had been exposed to an integrated pile dosage of $1 \times 10^{18}$ nvt would not support reversible dielectric polarization.

539.2 : 537.2

4385 MOLECULAR ROTATION AND DIELECTRIC RELAXATION IN A CRYSTAL LATTICE.
C.Clemett and M.Davies.
J. chem. Phys., Vol. 32, No. 1, 316-17 (Jan., 1960).

Dielectric dispersion measurements on liquid and solid succinonitrile, $NC.CH_2.CH_2.CN$, lead to ΔH values of 3.9 and 2.7 kcal/mole for the relaxation process in the two states.

W.J.Orville-Thomas

539.2 : 537.2

4386 SOME EFFECTS OF VAPORS ON ELECTRET BEHAVIOR.
J.R.Beeler, Jr, J.D.Stranathan and G.G.Wiseman.
J. chem. Phys., Vol. 32, No. 2, 442-6 (Feb., 1960).

The effects of various vapours on the growth and decay of electret polarization were studied. Particular emphasis was given to the effect of water vapour on polyvinyl acetate. The observed effects appear to arise from two causes : (1) a decrease in the relaxation time and an increase in the magnitude of the volume polarization following infusion of vapour into the dielectric; (2) an increase in the transfer of charge by means of interfacial discharge at the dielectric-electrode gap. The infusion of a polar vapour into a nonpolar solid dielectric gave anomalously large values of volume polarization. The dielectrics studied were polyvinyl acetate, polyethylene, two acrylic resins, and carnauba wax. The vapours used successfully were water and chlorobenzene, unsuccessfull attempts were made to use benzene and isopropyl ether.

539.2 : 537.2 : 77 : 621.319

4387 A REVIEW OF "ELECTROFAX" BEHAVIOR. J.A.Amick.

R.C.A. Rev., Vol.20, No. 4, 752-69 (Dec., 1959).

The physical, optical and electrical properties of Electrofax [Abstr. 2409 B (1955); R.C.A. Rev., Vol.15, No.4, 469-84 (Dec.,1954)] layers are reviewed, with special emphasis on the physical model for Electrofax developed by Rose, Gerritsen, and Ruppel. The characteristics of the latent images which can be formed in an Electrofax layer are discussed, together with techniques which can be used to make these latent images visible.

539.2 : 537.2 : 77 : 621.319

4388 A VOLUME-CHARGE CAPACITOR MODEL FOR "ELECTROFAX" LAYERS. J.A.Amick.

R.C.A. Rev., Vol.20, No.4, 770-84 (Dec., 1959).

Observed nonlinearities of the light discharge curves for Electrofax layers are ascribed to ionizable centres uniformly distributed throughout the volume of the dark-adapted layer. When the layers are corona charged, the centres are emptied leaving uncompensated positive charges within the layer. As a result, the charging—discharging characteristics of Electrofax layers are not the same as those for a simple capacitor. By determining the density of ionizable centres present in different Electrofax layers, light-discharge curves can be calculated which agree well with the experimentally observed curves.

## OPTICAL PROPERTIES OF SOLIDS

539.2 : 535

4389 OPTICAL CONSTANTS OF METALS. M.Suffczynski.

Phys. Rev., Vol. 117, No. 3, 663-71 (Feb. 1, 1960).

A calculation of the interband contribution to the frequency dependent dielectric constant of metals is attempted based on a specific model. The frequency region near the threshold for the interband transitions is considered. Emphasis in the model is laid on the bending of the energy bands near the Brillouin zone boundary. Attention is focused on cases when the Fermi surface approaches the zone boundary or has a finite area of contact with it. The momentum matrix element is taken as constant, which is fitted so as to achieve agreement with the experimentally found dip in the dispersion curve of the extinction coefficient. The values of the square of the matrix element for the noble metals, copper, silver, and gold, which fit the experimental data of Schulz, are found to be in the ratio 0.43 : 0.69 : 0.69.

539.2 : 535

4390 OPTICAL CONSTANTS OF UNDISTURBED METAL CRYSTALS. E.Menzel and M.Otter.

Z. Naturforsch., Vol. 14a, No. 11, 998-9 (Nov., 1959). In German.

Metals were crystallized in a tungsten boat in vacuum to obtain a single crystal of roughly spherical form. The optical constants of this were measured by Drude's method. The aim was to obtain values unaffected by surface conditions which could be used in the electron theory of metals. Results for copper in the visible region are given. W.T.Welford

539.2 : 535

4391 THE EFFECT OF LATTICE DEFECTS ON THE OPTICAL PROPERTIES OF METAL FILMS. J.Hasse.

Z. Phys., Vol. 157, No. 2, 166-88 (1959). In German.

The variation of the reflectivity and transmission of films of Bi, Ga, Sn and Ag during annealing was measured in the spectral range 0.25 to 4 μ. The optical constants are anomalous due to lattice defects frozen in, and behave rather like those of extremely thin films. The anomaly can be correlated with that of other physical properties, such as the electrical conductivity; the electronic mean free path derived purely from optical measurements is in agreement with that determined from the conductivity.

L.Pincherle

539.2 : 535

4392 MAGNETOPLASMA REFLECTION IN SOLIDS. B.Lax and G.B.Wright.

Phys. Rev. Letters, Vol. 4, No. 1, 16-18 (Jan. 1, 1960).

The sharp drop in reflectivity which occurs at the plasma frequency is shown to split into two edges, in general, when a steady magnetic field is applied. The theory is worked out for free electrons and the extension to more complex energy surfaces is indicated; it is shown that from the splitting an effective mass can be deduced for the carriers. Experimental results on InSb and HgS confirm the theory, and indicate effective masses of 0.041 $m_0$ and 0.045 $m_0$ respectively for the carrier electrons. R.G.Chamber

539.2 : 535 : 621.357.

4393 THE RELATIONSHIP BETWEEN BRIGHTNESS AND STRUCTURE IN ELECTROPLATED NICKEL.

R.Weil and R.Paquin.

J. Electrochem. Soc., Vol. 107, No. 2, 87-91 (Feb., 1960).

Nickel deposits of various brightnesses were plated from Watt baths containing several different addition agents. The as-plated surfaces of the deposits were examined by electron microscopy. All bright deposits had a very fine-grained structure. However, some fine-grained deposits showed surface crevices and were therefore not bright. A linear relationship between the fraction of the surface area having a roughness less than 0.15 μ and the logari of light reflected as measured with a photocell was found. There i no direct relationship between the degree of preferred orientation and brightness, but the fibre axis is related to the type of structure observed, i.e. platelet equiaxed crystallite, or spiral-type, and the addition agents in the plating bath.

539.2 : 535

4394 THE DISPLACEMENT WITH ANGLE OF INCIDENCE O THE MINIMUM OF THE REFLECTION COEFFICIENT OF SILVER IN THE ULTRAVIOLET REGION.

F.Abelès and F.Dorel.

C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2040-1 (Nov. 16, 1959). In French.

Previous authors have shown that the reflection coefficient of silver possesses a minimum in the ultraviolet which is displaced towards shorter wavelengths with increased angle of incidence. The presence of a thin surface film separating bulk silver from th air has been postulated to explain this variation. The present pape shows that the displacement can be explained completely by using the correct values of the complex refractive index of bulk silver, and the thin film hypothesis is unnecessary. R.W.Fi

539.2 : 535

4395 THE EFFECT OF THE ANGLE OF INCIDENCE OF LIGHT IN THE OBSERVATION OF THE ULTRAVIOLE REFLECTION MINIMUM OF SILVER.

G.P.Skornyakov and I.I.Sasovskaya.

Optika i Spektrosk.,Vol. 7, No. 2, 249-50 (Aug.,1959). In Russian.

With increase of the angle of incidence the reflection minimum of silver at 3200-3300 A was found to be gradually displaced towar shorter wavelengths and the value of the reflection coefficient rose in the region near this minimum. This displacement of the reflection minimum is ascribed to the participation in the process of reflection of layers with different defect densities. Since the defect density rises towards the silver layer surface, the greates displacement of the reflection minimum is observed in the case of large angles of incidence because then the path of the light wave in surface layer is longest. A.Tybulewi

539.2 : 535

4396 OPTICS OF THIN FILMS. II. PROPERTIES OF TELLURIUM. M.P.Lisitsa and N.G.Tsvelӯkh.

Optika i Spektrosk., Vol. 4, No. 3, 373-7 (1958). In Russian. English summary: PB 141047T-4 obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

For Pt I, see Abstr. 1626 (1958). Wedge films of Te were prepared on glass plates and the reflection from both sides and the transmission were measured as functions of wavelength and thickness of the film. From these data the complex refractive index wa calculated throughout the visible region. W.T.Welfo

539.2 : 5

PROPAGATION OF LIGHT IN CRYSTALS IN WHICH EXCITONS ARE FORMED. See Abstr. 4263

539.2 : 535

4397 STUDY OF THE WURTZITE-TYPE BINARY COMPOUNDS. IV. THEORY OF DOUBLE REFRACTION.

F.Keffer.

J. chem. Phys., Vol. 32, No. 1, 62-6 (Jan., 1960).

For Pt III, see Abstr. 6238 (1959). The Ewald-Born theory of ble refraction is applied to wurtzite-type compounds. Except the small distortion and polarization, these compounds have ntical near-neighbour symmetry to zinc blende (cubic) structures, hence the double refraction is caused primarily by the distant- ghbour interactions. The effects of anisotropy of the Lorentz— renz force and of the Coulomb force are calculated. In the nic) approximation of zero cation polarizability the theory predicts ouble refraction larger than the measured one by a factor ~ 2 all six compounds that have been measured. In the (covalent) roximation of zero effective ionic charge the theory underesti- tes the double refraction of AlN, but may be made to agree with measured values of the other compounds by a suitable choice of mic polarizabilities. In both approximations the theory predicts $< n_e$, in agreement with long-wavelength observations. Aniso- pic interaction of polarized light with the solid as a whole, as in iton transitions, seems to account for the inversion to $n_0 > n_e$, r the absorption edge of CdS.

539.2 : 535

### 4398 PHOTOELASTIC PROPERTIES OF PLASTICISED POLYMETHYL METHACRYLATE IN THE GLASSY ATE. J.H.Lamble and E.S.Dahmouch.

it. J. appl. Phys., Vol. 9, No. 20, 388-91 (Oct., 1958).

The stress-optical coefficient of polymethyl methacrylate sticized with dibutyl phthalate varies linearly from −4.55 Brew- rs (18° C) for the unplasticized polymer to +4.4 Brewsters for the sticized with 20% by weight dibutyl phthalate, being zero when the centage of this plasticizer is about ten. Another plasticizer, poly- ylene glycol, when used in the same proportion by weight as for utyl phthalate, has a much smaller influence on the stress-optical fficient. Optical creep reduces algebraically the value of the ess-optical coefficients. The influence of the proportion of the sticizer on the refractive index and the mechanical properties of plasticized polymers is also studied.

539.2 : 535

### 4399 ROTATORY DISPERSION IN HYDRATED COBALTOUS SALTS. M.J.Stephen.

lecular Phys., Vol.1, No.3, 301-4 (July, 1958).

The rotation of the plane of polarization per unit length has been lcuated theoretically for cobaltous salts and compares well with experimental measurements of Miescher (Abstr. 2495 of 1930).

R.W.Nicholls

539.2 : 535

### 4400 MAGNETO-OPTICAL ROTATION IN ALLOYS OF NICKEL WITH PALLADIUM.

N.Levkov and M.M.Noskov.

ptika i Spektrosk., Vol. 4, No. 3, 378-82 (1958). In Russian. nglish summary: PB 141047T-4 obtainable from Office of Technical rvices, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

Rotation of the plane of polarization of light reflected normally om magnetized Ni—Pd alloys was determined for from 0 to 90% omic Pd. The Curie points of the alloys used are given.

W.T.Welford

539.2 : 535

### OPTICS OF ABSORBING MAGNETIC CRYSTALS.

ee Abstr. 3651-2

539.2 : 535.3

### 4401 ON THE TRANSPARENCY OF THE ALKALI METALS IN THE ULTRAVIOLET. M.Gourceaux.

.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2020-2 (Nov. 16, 1959). French.

A discussion is given of the way in which the Drude—Zener for- ula for the complex index of refraction (n - ik) fails for the alkali etals in the ultraviolet. An alternative representation is discussed, howing the way in which the changes in n and k are predicted.

G.H.C.Freeman

539.2 : 535.3

### 4402 ABSORPTION AND DISPERSION OF THIN LAYERS OF GOLD. A.N.Tekuchev.

ptika i Spektrosk., Vol. 7, No. 1, 93-6 (July, 1959). In Russian.

The refractive index and the absorption coefficient of gold yers 500, 115 and 50 A thick, deposited on glass substrates by puttering, were determined by analysing the ellipticity of mono- hromatic light reflected from them. Two dispersion and two bsorption minima were observed in the visible region. Micro- tructure of the layers is also discussed.

A.Tybulewicz

539.2 : 535.3

### 4403 CERTAIN DISPERSION ANOMALIES OF STRONGLY ABSORBING CRYSTALS.

M.S.Brodin, A.F.Prikhot'ko and M.S.Soskin.

Optika i Spektrosk. Vol. 7, No. 2, 266-7 (Aug., 1959). In Russian.

Describes studies of anomalous dispersion regions in thin crystals of 1, 2-benzanthracene and anthracene. At low temperatures interference fringes in the region of the first long-wavelength absorption band of 1,2-benzanthracene (0.25 μ thick) were apparently split into two and overlapping; this is not predicted by the usual theory of anomalous dispersion. In the case of anthracene the splitting and overlapping of interference bands at the absorption maxima was observed both at low and at room temperatures. It is suggested that the observed effect is due to propagation of two identically polarized waves with unequal path differences. Two waves, which are not due to the usual birefringence, were recently predicted for the region of exciton absorption in crystals, and it is suggested that this may explain the observed anomalies.

A.Tybulewicz

539.2 : 535.3

### 4404 THE ABSORPTION EDGE OF ARSENIC-SULPHUR-SELENIUM MIXTURES. C.Hilsum.

Proc. Phys. Soc., Vol. 74, Pt 5, 667-9 (Nov., 1959).

The transmission of 1 micron thick evaporated layers of $As_2S_3$, $As_2S_5$, $As_2Se_3$ and $As_2Se_5$ was measured. All four compounds showed the steep rise in transmission at a certain wavelength which is characteristic of semiconductors, this absorption-edge being at 0.48μ for $As_2S_5$, 0.5μ for $As_2S_3$ and 0.64μ for both $As_2Se_3$ and $As_2Se_5$. Mixtures of $As_2S_5$ and $As_2Se_5$ were also evaporated, and it was found that the edge moved progressively towards the red as the proportion of selenide was increased. Similar results were obtained for mixtures of $As_2S_3$ and $As_2Se_3$. Stable optical filters with a cut-off anywhere between the yellow and the red could be made in this way.

C.Hilsum

539.2 : 535.33

### 4405 THE EFFECT OF PRESSURE ON THE ABSORPTION EDGE OF $BaTiO_3$ AND $TiO_2$.

H.L.Suchan, A.S.Balchan and H.G.Drickamer.

J. Phys. Chem. Solids, Vol. 10, No. 4, 343-4 (Aug., 1959).

The absorption shifts were measured for an absorption coefficient ~75 in a region where the absorption was considerably larger than the reflection for samples 0.004-0.010 in. thick. The shape of the edge was independent of hydrostatic pressures up to about 150 000 atm for $BaTiO_3$ and to 100 000 atm for $TiO_2$. There was a small red-shift for $BaTiO_3$ and blue shift for $TiO_2$ which increased with increasing pressure.

C.A.Hogarth

539.2 : 535.33

### 4406 THE EFFECT OF PRESSURE ON THE ABSORPTION EDGE IN HEAVY-METAL HALIDES.

J.C.Zahner and H.G.Drickamer.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 92-6 (Sept., 1959).

The effect of pressure has been measured on the absorption edge of ten heavy-metal halides. In general, a large decrease in the gap is obtained with increasing pressure. The differences between the data on thallous halides and previous data on AgCl and AgBr are explained tentatively in terms of differences in band structure postulated by Seitz and Martienssen. Compounds which crystallize in the same lattice show closely similar shifts with pressure (or density) regardless of the halide involved. $HgI_2$ returns to the high-temperature form above 13 000 atm at room temperature, as has been previously noted by Bridgman.

539.2 : 535.33

### 4407 THE EFFECT OF PRESSURE ON THE ABSORPTION EDGE OF CERTAIN MOLECULAR COMPOUNDS.

H.L.Suchan and H.G.Drickamer.

J. Phys. Chem., Solids, Vol. 11, No. 1-2, 111-14 (Sept., 1959).

The effect of pressure has been measured on the optical absorption edge of certain molecular crystals, including $Hg_2Cl_2$, $Hg_2Br_2$, $Hg_2I_2$, $CI_4$, $SnI_4$, $CBr_4$, $SnBr_4$ and $CI_3H$. In general, the gap decreases with pressure at a rate which tends to accelerate with increasing pressure. The rate of shift of the edge depends strongly on the halogen involved, in contrast to ionic crystals where the shift of the edge depends largely on the structure and the cation An extrapolation of the data indicates that by 300 000 atm most molecular iodides would have zero optical gap.

539.2 : 535.33

### 4408 THE EFFECT OF PRESSURE ON ZINC BLENDE AND WURTZITE STRUCTURES.

A.L.Edwards, T.E.Slykhouse and H.G.Drickamer.
J. Phys.Chem. Solids, Vol. 11, No. 1-2, 140-8 (Sept., 1959).

The effect of pressure has been measured on the absorption edges of GaP, GaAs, GaSb, ZnS, ZnSe, ZnTe, ZnO and CdS. A tentative interpretation can be given consistent with previous work on silicon and germanium. Regularities in the shifts in horizontal and diagonal sequences are discussed. An absorption peak which appears (irreversibly) on the low-energy side of the edge of the higher-molecular-weight compounds, and grows with pressure, indicates either the formation of a disordered phase or some chemical decomposition. For GaAs and GaSb both events may be present, but for ZnTe the former course seems definitely more probable.

539.2 : 535.33

### 4409 THE EFFECT OF THICKNESS OF ANTHRACENE CRYSTALS ON THEIR ABSORPTION CURVES AT 20°K.

M.S.Brodin and A.F.Prikhot'ko.
Optika i Spektrosk., Vol. 7, No. 1, 132-3 (July, 1959). In Russian.

Plane-parallel monocrystalline layers of anthracene were prepared by sublimation onto quartz plates. Their optical density was measured photoelectrically. The absorption coefficients were calculated from the measured optical density, corrected for reflection losses. The absorption-coefficient curves of the crystals were found to depend on their thickness (under 1 μ). This dependence was observed at 20°K and not at room temperature. It is suggested that the low-temperature anomalies may be due to the exciton absorption formulae being inapplicable at 20°K.

A.Tybulewicz

539.2 : 535.33

### 4410 INVESTIGATION AND INTERPRETATION OF BANDS IN THE ABSORPTION SPECTRA OF CRYSTALS COLOURED WITH CHROMIUM IONS.

I.I.Antipova-Karataeva.
Optika i Spektrosk., Vol. 7, No. 2, 263-5 (Aug., 1959). In Russian.

Reports a study of the absorption spectra of $Cr^{3+}$-coloured crystals of the $KCr(SO_4)_2.12H_2O$ alum and the artificial ruby ($Al_2O_3-Cr_2O_3$), as well as the spectra of the alum solutions in water. Two wide bands (at 17 400 and 24 300 $cm^{-1}$) were observed at all concentrations of the alum solutions. In the alum crystals three bands were observed at 17 700, 24 600 and 38 750 $cm^{-1}$; three bands were also observed in the artificial ruby at 17 750, 24 700 and 39 500 $cm^{-1}$. The three bands observed in solids are ascribed to configuration exchange interaction between levels of the same symmetry $F_{1g}$ but belonging to terms with different orbital quantum numbers L.

A.Tybulewicz

539.2 : 535.33

### 4411 VIBRATION SPECTRA AND STRUCTURE OF AMMONIUM THIOCYANATE CRYSTALS.

A.Tramer.
C.R. Acad. Sci. (Paris), Vol. 249, No. 25, 2755-7 (Dec. 21, 1959). In French.

Wave-numbers and assignments of infrared and Raman lines are listed. The spectra indicate hydrogen bonding with N of the ion $(CNS)^-$. The structure is contrasted with that of KCNS.

G.F.Lothian

539.2 : 535.33

### 4412 ULTRAVIOLET ABSORPTION SPECTRA OF ANODIC ZIRCONIUM OXIDE FILMS.

R.E.Saloman, W.M.Graven and G.B.Adams Jr.
J. chem. Phys., Vol. 32, No. 1, 310-11 (Jan., 1960).

Zirconium foils 0.0008 in. thick were anodically oxidized on one side in sodium borate—boric acid solution, and the remaining zirconium was removed by etching. The transmission of the $ZrO_2$ films was measured from 2000 - 7000 A. An absorption edge was observed near 2300 A. Absorption indices were calculated from 2000 to 2400 A.

C.Hilsum

539.2 : 535.33

### 4413 CRYSTAL SPECTRA OF METAL COORDINATION COMPOUNDS. I. TETRAHEDRAL COBALT(II).

J.Ferguson.
J. chem. Phys., Vol. 32, No. 2, 528-32 (Feb., 1960).

A reflecting microscope was used to measure the absorption spectra, in polarized light, of a number of cobalt(II) compounds in which the ligands are arranged tetrahedrally. These compounds are $Cs_3CoCl_5$, cobalt di-p-toluidine dichloride, cobalt dipyridine dibromide, and cobalt dipyridine diiodide. The two transitions, $^4A_2 \rightarrow {}^4T_1(F)$ in the near infrared and $^4A_2 \rightarrow {}^4T_1(P)$ in the visible, were compared in the different compounds and the effect of symmetry discussed. It was also found that the crystal spectra of all but $Cs_3CoCl_5$ are modified by interaction between the complexes in the crystal so that the energy levels are not accurately described by the field of the ligands only.

539.2 : 535.33

### 4414 CRYSTAL SPECTRA OF METAL COORDINATION COMPOUNDS. II. VIOLET FORM OF $CoPy_2Cl_2$ AND $CoCl_2 \cdot 6H_2O$.

J.Ferguson.
J. chem. Phys., Vol. 32, No. 2, 533-7 (Feb., 1960).

A microspectrophotometric study of the visible polarized crysta spectra of the violet form of cobalt dipyridine dichloride and cobalt chloride hexahydrate is reported. An analysis of the band structure of the former is made in terms of noninteracting, complex units, but in the latter, interaction between a cobalt ion and the chloride ions on next nearest neighbour complexes, in addition to the ligands, is needed for a successful analysis of the spectrum.

539.2 : 535.33

### 4415 SIMULTANEOUS ELECTRONIC AND VIBRATIONAL TRANSITIONS IN THE SPECTRA OF HYDRATED NICKEL(II) ION.

T.S.Piper and N.Koertge.
J. chem. Phys., Vol. 32, No. 2, 559-61 (Feb., 1960).

A series of weak bands at about 19 000 $cm^{-1}$ was found in the visible spectra of the hydrated nickel(II) ion in several crystals. These bands are assigned to simultaneous electronic and vibrationa transitions involving the H—O stretching vibration. This assignment was confirmed by observation of an isotopic shift upon deuteration.

539.2 : 535.3

### 4416 ON THE INFRARED ABSORPTION OF QUARTZ IN THE 3 μ REGION.

G.Brunner, H.Wondratschek and F.Laves.
Naturwissenschaften, Vol. 46, No. 24, 664 (1959). In German.

Treatment in $D_2O$ vapour confirms that certain bands in the 3μ region are due to adsorbed OH. There is a close correspondence across a crystal between the intensity of such OH bands and the intensity of coloration induced by neutron irradiation.

G.F.Lothi

539.2 : 535.33

### 4417 A STRONG ABSORPTION SYSTEM IN TYPE I DIAMONDS.

F.A.Raal.
Proc. Phys. Soc., Vol. 74 Pt 5, 647-9 (Nov., 1959).

Thin parallel slabs of Type I diamond are studied. Polished plates in thickness from 0.04 to 0.50 mm were used. The existence of bands at 2290-2310 and at 2350-2370 A is demonstrated. They are designated $N_9$. They constitute the strongest natural absorptio band system found in Type I diamonds to date.

S.Tolansk

539.2 : 535.33

### 4418 ZEEMAN SPLITTINGS OF PARAMAGNETIC ATOMS IN CRYSTALLINE FIELDS.

H.Statz and G.F.Koster.
Phys. Rev., Vol. 115, No. 6, 1568-77 (Sept. 15, 1959).

For previous work, see Abstr. 4825 (1959). This paper deals with the energy levels as a function of magnetic field of paramagnet ions in crystalline surroundings. The necessary information is giv to write down the Hamiltonian matrix for ions in common crystallin fields. The method has been previously developed and consists of determining the Hamiltonian matrix of $\beta H \cdot (L + 2S)$ for the lowest states of an ion by the methods of group theory and time inversion considerations. The Hamiltonian matrix contains a certain number of undetermined constants which may be evaluated if the wave-functions of the ions are known or the constants may be determined from experiment. In general, the number of available constants is larger than found in the conventional spin Hamiltonian formalism. The present method may be applied in cases where the conventional spin Hamiltonian formalism is inadequate to describe experimental results or where greater accuracy is required.

539.2 : 535.33 : 537.5

### 4419 SPECTROSCOPIC STUDY OF THE PRODUCTS OF ELECTRIC DISCHARGE IN NITROGEN CONDENSED TO THE SOLID STATE AT VERY LOW TEMPERATURE; TESTS IN FAVOUR OF THE EXISTENCE OF TRIATOMIC NITROGEN IN THE SOLID.

M.Peyron, E.M.Horl, H.W.Brown and H.P.Broida.
J. Chim. phys., Vol. 56, No. 8-9, 736-44 (Aug.-Sept., 1959). In French.

Emission bands in ultraviolet, visible and near infrared observ ographically and with a PbS photocell are attributed to the ecule $N_2$—N, electronic changes in N being accompanied by ational changes in the loosely bound $N_2$. This is confirmed by eriments with isotopic mixtures. G.F.Lothian

539.2 : 535.33 : 537.52

### 4420 STUDY IN THE INFRARED OF CERTAIN SOLIDS CONDENSED AFTER A DISCHARGE IN THE GASEOUS ASE.

K.B.Harvey and H.W.Brown.

Chim. phys., Vol. 56, No. 8-9, 745-8 (Aug.-Sept., 1959). In French.

Products of the discharge were condensed on a CsI plate at low nperature and the absorption spectrum observed in the region 00 A to 25 μ. Discharges in $H_2O$, $H_2O_2$, $N_2$ do not give rise to any e radicals. Discharge in a mixture of $H_2$ (or $D_2$) with NO and A es the radical HNO. From the observed infrared vibration bands, ence force constants are calculated. G.F.Lothian

539.2 : 535.33

### 4421 RAMAN SPECTRUM OF CRYSTALLINE α-GLYCINE.

R.S.Krishnan and K.Balasubramanian.

oc. Indian Acad. Sci. A, Vol. 48, No. 2, 55-61 (Aug., 1958).

Raman spectrum of a single crystal of α-glycine has been otographed using 2536.5 excitation. 35 Raman lines have been corded with frequency shifts 53, 74, 90, 109, 164, 183, 199, 358, ), 588, 677, 697, 896, 925, 1038, 1112, 1140, 1320, 1330, 1395, 4, 1441, 1459, 1506, 1563, 1640, 1668, 2530, 2630, 2750, 2830, 5, 2974, 3008 and 3145. Of these 17 have been recorded for the st time. The 6 intense lattice lines 53, 74, 109, 164, 183 and 199 e been attributed to the rotational oscillations of the 4 molecules glycine contained in the unit cell of the crystal. Assignments ve also been made for all the prominent internal frequencies. e present study confirms the existence of $-^{+}NH_3$ groups and the ization of the carboxyl group even in the crystal.

539.2 : 535.33 : 548.5

### 4422 CONTRIBUTION TO THE STUDY BY THE RAMAN EFFECT OF CRYSTALLINE SULPHATES OF THE AGNESIUM SERIES, $MSO_4 \cdot 7H_2O$ [M = Mg OR Zn].

R.Lafont.

n. Phys. (Paris), Ser. 13, Vol. 4, No. 7-8, 905-63 (July-Aug., 1959) French.

A thermo-syphon method of obtaining large crystals from lution is described. Observed Raman lines are attributed to vibrations of the ion $SO_4^{2-}$, for which a theory is developed; wer lines than predicted are found. (2) Internal vibrations of e ion $M(H_2O)_6$. (3) Low frequency vibrations of the whole lattice. G.F.Lothian

539.2 : 535.37 : 532.7

### 4423 ON THE DETERMINATION OF CRITICAL MOLECULAR SPACING FOR CONCENTRATION-DEPOLARIZATION F FLUORESCENCE.

C.Bojarski and A.Kawski.

n. Phys. (Leipzig), Folge 7, Vol. 5, No. 1-2, 31-4 (1959). German.

A simple method is given for the determination of the critical olecular distance $R_0$ for the concentration depolarization of minescence, for which the emission probability is the same as the ansition probability for the excitation. The calculated value of $R_0$ r fluorescein and rhodamin B in glycerin is 55A and 63A respecvely and is 32A for anthracene in polystyrene. G.F.J.Garlick

539.2 : 535.37

### 4424 CALCULATION OF EMISSION SPECTRA BY USE OF MULTI-COORDINATE CONFIGURATIONAL DIAGRAMS.

.Curie.

.R. Acad. Sci. (Paris), Vol. 249, No. 19, 1884-6 (Nov. 9, 1959). French.

If each atomic position in an emission centre is specified by a eparate coordinate the emission bands remain Gaussian in form, ssuming the Franck—Condon conditions, in the same way as for a ingle generalized coordinate. Each coordinate provides a partial scillator contribution and these add quadratically to give the band ntensity. G.F.J.Garlick

539.2 : 535.37

### 4425 CALCULATION OF EMISSION SPECTRA IN THE CONFIGURATION COORDINATE MODEL. A SIMPLE NTERPRETATION OF THE RESULTS.

D.Curie.

.R. Acad. Sci. (Paris), Vol. 250, No. 5, 834-6 (Feb. 1, 1960). n French.

A simple derivation is shown for bandwidths of emission and absorption at absolute zero, for the increase of bandwidth with temperature rise, and for band displacement with temperature. S.T.Henderson

539.2 : 535.37

### 4426 A NEW POSSIBILITY OF EXPLAINING THE DEPENDENCE OF THE LUMINESCENCE QUANTUM YIELD ON THE WAVELENGTH OF THE EXCITING LIGHT.

V.L.Broude and V.S.Medvedev.

Dokl. Akad. Nauk SSSR, Vol. 129, No. 3, 533-5 (Nov. 21, 1959). In Russian.

In order to study the spectra of luminescence excitation for substances in which the exciton mechanism of energy transfer is excluded, the solid solutions of anthracene (in polystyrene) were investigated by means of two monochromators. While the quantum yield was virtually constant (in the range 3900-3200 A) for anthracene in liquid styrene and for the solution of anthracene in previously polymerized polystyrene, it showed several maxima and minima in the same wavelength range for the solid polymerized solution of anthracene in styrene. F.Lachman

539.2 : 535.37

### 4427 THE PROBLEM OF EXISTENCE AND THE NATURE OF TRUE "CANDOLUMINESCENCE".

V.A.Sokolov.

Optika i Spektrosk, Vol. 4, No. 3, 409-11 (1958). English summary: PB 141047T-4 obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A. In Russian.

An experimental arrangement is described in which a phosphor coated on the outside of an efficiently cooled brass cylinder placed in a bunsen flame enables true candoluminescence to be observed at temperatures below those at which luminescence would be thermally quenched. Emission spectra for a ZnS-CdS-Cu phosphor are identical with those of cathodo- and photoluminescence. Excitation is attributed to higher energy electrons, atoms and ions in the bunsen flame or perhaps to energy from recombination of ions at the phosphor surface. G.F.J.Garlick

539.2 : 535.37

### 4428 THE SIMULTANEOUS ACTION OF LIGHT AND ELECTRIC FIELDS ON PHOSPHORS.

L.A.Vinokurov and M.V.Fok.

Optika i Spektrosk., Vol. 7, No. 2, 241-3 (Aug., 1959). In Russian.

The effects of light and electric fields were found to be non-additive: in some cases the luminescence brightness due to simultaneous excitation was higher and in other cases it was lower than the sum of the brightnesses of both types of luminescence. In two ZnS:Cu,Al phosphors the maximum observed non-additivity amounted to about 10%. The authors show that the exact additivity can be obtained when A/B = const., where A and B are the number of acts of ionization of luminescence centres per unit volume and per unit time due to light and due to electric field respectively. A.Tybulewicz

539.2 : 535.37 : 532.7

### 4429 THE DELAYED LIGHT EMISSION OF SCINTILLATOR MATERIALS IN THE MICROSECOND REGION.

K.Einfeld.

Z. Naturforsch., Vol. 14a, No. 11, 966-71 (Nov., 1959). In German.

Excitation was by 0.5 μsec pulses of 200 kV X-rays at msec intervals, while the light output at any point was measured by a photomultiplier energised for 0.2 μsec periods suitably related to the excitations. The results and previous work are tabulated for p-terphenyl in m-xylol, a plastic scintillator, anthracene, NaI:Tl and CsI:Tl. The liquid shows only one decay component, but for the others a resolution into several exponentials is made, and their time constants and percentage contributions recorded. S.T.Henderson

539.2 : 535.37

### 4430 DETERMINATION OF THE LUMINESCENCE ENERGY YIELD OF PLASTIC SCINTILLATORS SUBJECTED TO γ-RAY RADIATION.

I.Ya.Breido, Yu.A.Tsirlin and L.N.Shishova.

Optika i Spektrosk., Vol. 7, No. 1, 89-92 (July, 1959). In Russian.

Describes a determination of the energy yield (defined as the efficiency of transformation of the energy of incident radiation into light energy) of γ-luminescence of a plastic scintillator, which was a solution of 2% terphenyl and 0.1% POPOP in polystyrene. The energy yield was measured for scintillations due to Compton electrons produced by γ-rays from $Cs^{137}$ and was found to be 0.017 ± 0.003. A.Tybulewicz

539.2 : 535.37

### 4431 KINETICS OF PHOTO- AND $\gamma$-LUMINESCENCE IN CERTAIN Tl-ACTIVATED ALKALI-HALIDE CRYSTALS.

I.K.Plyavin'.

Optika i Spektrosk., Vol. 7, No. 1, 71-7 (July, 1959). In Russian.

$Co^{60}$ was used as the $\gamma$-ray source and a 3500 V spark of ~ $10^{-8}$ sec duration was used to excite photoluminescence. Scintillations of photo-excited NaI:Tl, KI:Tl, CsI:Tl, KCl:Tl and $\gamma$-activated NaI:Tl, KI:Tl, CsI:Tl decayed exponentially; in the case of $\gamma$-excitation the decay curve could be represented as the sum of several exponentials. A.Tybulewicz

539.2 : 535.37

### 4432 LUMINESCENCE OF ALKALI-HALIDE COMPOUNDS WITH URANYL SALT IMPURITIES.

I.P.Shapiro.

Optika i Spektrosk., Vol. 7, No. 1, (July, 1959). In Russian.

The author found that powders of KBr, KCl, KF and NaCl deposited from aqueous solutions with small amounts of ammonium uranyl sulphate, $(NH_4)_2UO_2(SO_4)_2.2H_2O$, luminesce strongly at room temperature under the action of near ultraviolet. The intensity of luminescence increases from KBr to KF. Melts of these compounds also luminesce strongly at ~1000° C, and the intensity of this luminescence increases with the time (15-30 min) spent by this compound in the melting furnace. When these compounds are melted in an atmosphere of nitrogen no luminescence is observed. The author suggests that the behaviour of the melts can be explained by assuming formation of a hexavalent ion $U^{6+}$ on diffusion of oxygen ions into the melt. The luminescence spectra of NaCl and KCl powders with various amounts of ammonium uranyl sulphate are also given and discussed in the paper. A.Tybulewicz.

539.2 : 535.37

### 4433 LUMINESCENCE CENTRES IN ALKALI-HALIDE PHOSPHORS WITH LARGE CONCENTRATIONS OF THE ACTIVATOR AND OF MICRODEFECTS OF THE HALIDE LATTICE.

T.Abdusadykov.

Optika i Spektrosk., Vol. 7, No. 2, 250-3 (Aug., 1959). In Russian.

Seventeen phosphors based on NaCl, KCl, NaBr, KBr and $NH_4Br$ and activated with $In^+$, $Tl^+$, $Sn^{++}$ and $Pb^{++}$ were studied. At high activator concentrations and high lattice-defect densities additional centres appeared in all thallium-activated phosphors and in all phosphors with mercury-like activator ions and sodium halide bases (NaCl:In, NaCl:Tl, NaCl:Pb, NaBr:In and NaBr:Tl). In all these phosphors the activator-ion radii are larger than the cation radii of the phosphor base. In KCl and KBr activated with indium, tin or lead new luminescence centres did not appear in the range of activator concentrations and microdefect densities employed in these studies. As a preliminary hypothesis is is suggested that the new luminescence centres are complexes consisting of activator ions and lattice defects. A.Tybulewicz

539. 2 : 535.37

### 4434 ENERGY TRANSFER IN MOLECULAR COMPLEXES. II. THE ANTHRACENE-SYM-TRINITROBENZENE COMPLEX.

S.P.McGlynn, J.D.Boggus and E.Elder.

J. chem. Phys., Vol. 32, No. 2, 357-61 (Feb., 1960).

For Pt I, see J. Amer. Chem. Soc., Vol. 80, No. 19, 5096 (Oct. 5, 1958). The emission spectrum of the anthracene-sym-trinitrobenzene complex was investigated in a solid solution in a diethylether-isopentane (EP) glass at 77° K. The observed luminescence consists of two distinct electronic transitions: one transition is the reverse of the charge-transfer E←N absorption of the complex; the other transition is a phosphorescence very similar to the T→S emission of anthracene in EP, but blurred somewhat in vibrational structure, blue shifted by 113 $cm^{-1}$, decreased in lifetime by a factor of about 2 and showing decreases in the ground state vibrational frequencies of a few percent. These results, as opposed to previous conclusions, would suggest that the phosphorescence is truly a T→S process of the complex which is largely localized on the anthracene component. Vibrational analyses of T→S spectra of anthracene in EPA and in EP and of the T→S and E→N spectra of the complex in EP at 77° K are given.

539.2 : 535.37

### 4435 ON THE U.V. EMISSION OF LEAD-ACTIVATED BORATE PHOSPHORS IN RELATION TO ACTIVATOR CONTENT AND THE TEMPERATURE.

H.Witzmann and R.Müller.

Z. phys. Chem. (Leipzig), Vol. 211, No. 5-6, 307-23 (1959). In German.

See Abstr. 1306 (1959). Emission spectra of the group II borates were obtained by microphotometry of spectral photographs. At -180° C a band with a peak near 25 000 $cm^{-1}$ appears in all the phosphors, and also in the Ca borate without Pb. The ultraviolet emission increases to a maximum at room temperature and then falls. Emission bands are shown for temperature up to 200° C. For the Sr borate the ultraviolet emission is close to a single Gaussian curve, while for the Ca and Be compounds it can be approximated by the sum of 2 or 3 Gaussians respectively. S.T.Henderso

539.2 : 535.37

### 4436 THE EFFECT OF ULTRAVIOLET RADIATION AND TEMPERATURE ON LUMINESCENCE OF $CdI_2$:$MnCl_2$ AND $CdI_2$:$MnCl_2$:$PbI_2$ PHOSPHORS.

G.P.Balin.

Optika i Spektrosk., Vol. 6, No. 6, 760-3 (June, 1959). In Russian.

Describes studies of the effects of ultraviolet irradiation and of temperature (acting separately and together) on the 675 mμ red luminescence band of $CdI_2$ phosphors activated with $MnCl_2$ and $MnCl_2$+$PbI_2$. After one hour of ultraviolet irradiation at 20° C the red emission fell considerably, but it was partly re-established after 44 hours in darkness, then further irradiation produced a similar effect. Phosphors with larger amounts of $MnCl_2$ were less affected by ultraviolet radiation because thermal motion and presence of a sufficient number of Mn ions rapidly re-formed Mn luminescent centres (responsible for the red emission), which were continuously destroyed by ultraviolet radiation. At low temperatures the red emission disappeared completely. Its intensity rose with temperature up to about 60° C and then fell off rapidly (at 300° C the red emission intensity was 11 times smaller than at 60° C). A.Tybulewicz

539.2 : 535.37

### 4437 THE MEASUREMENT OF THE TEMPERATURE DEPENDENCE OF THE LUMINESCENCE OF CdS.

K. Albers.

Z. Naturforsch., Vol. 14a, No. 11, 1002-3 (Nov., 1959). In German.

CdS crystals which have lost their red emission by prior heating at 100-200° C have this luminescence restored by heating in the dark to 150-200° C, under a vacuum of $10^{-4}$ to $10^{-5}$ mm Hg, but the emission is fugitive. It is more permanent if the cooling after the heat treatment occurs under strong irradiation by yellow light. S.T.Henderson

539.2 : 535.37

### 4438 THE TEMPERATURE DEPENDENCE OF THE LUMINESCENCE OF CdS CRYSTALS. I : CRYSTALS WITHOUT FOREIGN ACTIVATORS.

R.Link and R.Seiwert.

Z. phys. Chem. (Leipzig), Vol. 212, No. 5-6, 295-318 (1959). In German.

The purest available crystals were tested between −200 and +200° C under 3650 A excitation, with measurement of intensities near the band peaks (5150, 5800, and 7100 A) and spectrophotometry of the whole visible emission. All crystals gave a green band with maximum intensity at the lowest temperature reached. The crystal were classified according to the behaviour of the red emission, whic showed three types of temperature dependence : a maximum at −50° C, or at −200° C, or two maxima at −200° and 0° C. The maximu of the orange band was −150° C. Plots of the measurements are given, and the data discussed at length without a decision on the type of luminescent transition involved, through a tentative band diagram is included. It is possible that the orange band arises from traces of impurity, while the red emission may depend on a partial convers of the original green band by self-absorption. S.T.Henderso

539.2 : 535.37

### 4439 THE TEMPERATURE DEPENDENCE OF THE LUMINESCENCE OF CdS CRYSTALS. II : CRYSTALS WITH Mn, Fe, Co or Ni INCORPORATED.

W.Boldt and R.Seiwert.

Z.phys. Chem. (Leipzig), Vol. 212, No. 5-6, 319-44 (1959). In German.

For Pt I see preceding abstract. The crystals probably contain $\ngtr$ 0 01% of foreign atoms; their emission bands were measured at 5150, 6250, and 7700 A, and some data obtained on the visible end of an infrared band. Curves show the temperature dependence of the bands between −184 and +200° C, and the whole spectral distribution at various temperatures. Few crystals had the green emission, the orange band was at a maximum at −100° C, and the red band ( peak ~ 7850 A) showed variable behaviour. Overall light output was highest for crystals containing Mn, with maximum at −50° C, where as for Fe impurity the maximum was at 100° C. Co and Ni produced only low efficiency. The temperature dependence of efficiency is discussed, especially for the red band which also varies in position S.T.Henderso

539.2 : 535.37

### 4440 LUMINESCENCE OF NON-ACTIVATED CsI MONOCRYSTALS. Z.L.Morgenshtern.

tika i Spektrosk., Vol. 7, No. 2, 231-5 (Aug., 1959). In Russian.

Photoluminescence spectrum of pure CsI monocrystals was in form of a wide band with a maximum near 4200 A and a half-width about 0.44 eV. Similar luminescence was observed under the tion of $\gamma$-rays from Co$^{60}$. It is possible to explain this non- tivated emission in two ways. Lattice defects may give rise to an sorption band lying on top of the fundamental absorption edge. ght absorbed by this band is then re-emitted as the non-activated minescence in pure CsI or it is shared between the non-activated d activator components of luminescence in CsI:Tl or CsI:In. ternately the two absorption bands of the CsI lattice itself, which e known to lie next to the fundamental edge (at ~ 219 and ~ 206 m$\mu$) y be responsible.

A.Tybulewicz

539.2 : 535.37

### 4441 LUMINESCENCE OF COPPER-ACTIVATED CALCIUM AND STRONTIUM ORTHOPHOSPHATES.

L.Wanmaker and C.Bakker.

Electrochem. Soc., Vol. 106, No. 12, 1027-32 (Dec., 1959).

Copper produces a strong luminescence in $Ca_3(PO_4)_2$. Lumines- nce in $Sr_3(PO_4)_2$ occurs only in the presence of small amounts of reign ions such as Ca, Zn, Cd, Mg, or Al. These additions give se to a new crystal phase which is probably isomorphous with $Ca_3(PO_4)_2$. The emission peaks under excitation with 2537 A of $Ca_3(PO_4)_2$, $\alpha$-$Ca_3(PO_4)_2$, and of $Sr_3(PO_4)_2$ modified with Al are found 4800, 5700, and 4950 A, respectively. Sensitization occurs with n, giving rise to a red emission peak. The temperature dependence the fluorescence is good, especially that of $\beta$-$Ca_3(PO_4)_2$-Cu and $_3(PO_4)_2$ partly substituted with Mg and Ca. Phosphor application in mps presents difficulties due to materials' sensitivity to air at nder bake-out temperatures.

539.2 : 535.37

### 4442 THE ELECTRICAL CONDUCTIVITY OF SILVER ACTIVATED CALCIUM METABORATE PHOSPHORS.

Witzmann and L.Schwarz.

phys. Chem. (Leipzig), Vol. 213, No. 1-2, 74-88 (1960). In German.

The electrical conductivity of pure and silver activated speci- ens with excess boron trioxide was measured. P-type conductivity as found in unactivated specimens. The activation energy for con- ctivity dependence on temperature shows a power law relation to the lver content. Non-luminescent specimens show the conductivity aracteristics of the pure borate.

G.F.J.Garlick

539.2 : 535.37

### 4443 TIN-ACTIVATED CALCIUM ORTHOSILICATE PHOSPHORS. R.W.Mooney.

Electrochem. Soc., Vol. 107, 100-4 (Feb., 1960).

Two phosphors are discussed : a blue-emitting phosphor with very broad excitation band having the $\beta$-$Ca_2SiO_4$ structure, and a ellow-emitting phosphor with fair response to high-pressure ercury-vapour radiation having the $\alpha'$-$Ca_2SiO_4$ structure. The -$Ca_2Sio_4$ :Sn phosphor is the more efficient of the two, comparing ery favourably with other well-known blue phosphors. The efficiency f $\beta$-$Ca_2Sio_4$ :Sn was studied as a function of activator concentration nd compared with similar results for $\beta$-$CaSiO_3$ :Sn. The difference n behaviour between $\beta$-$Ca_2SiO_4$ :Sn and $\beta$-$CaSiO_3$ :Sn is attributed to ifferences in crystal structure.

539.2 : 535.37

### 4444 COPPER AND TIN-ACTIVATED HALOPHOSPHATE PHOSPHORS. B.E.Hunt and A.H.McKeag.

J. Electrochem. Soc., Vol. 106, No. 12, 1032-6 (Dec., 1959).

New copper- and tin-activated halophosphate phosphors, fired n mildly reducing atmospheres and of potential practical import- ance, are described. They include copper- and tin-activated barium chlorophosphates with good thermal characteristics. Copper- activated barium chlorophosphate shows a moderate red fluores- cence at ambient temperatures, under long u.v. excitation, which be- comes brighter at higher temperatures due to a marked colour shift toward the yellow. The same matrix, activated with tin, shows a strong pale green fluorescence at ambient temperatures when excited by 2537 A radiation which is shifted toward the blue at elevated temperatures.

539.2 : 535.37

### 4445 LUMINESCENT PROPERTIES OF SILVER-ACTIVATED MAGNESIUM BORATE PHOSPHORS.

Y.Uehara, Y.Kobuke and I.Masuda.

J. Electrochem. Soc., Vol. 107, 104-7 (Feb., 1960).

Silver-activated magnesium borate phosphors are extremely sensitive to reducing agents in the presence of water or moist air. With progressive reduction, the colour of fluorescence turns from bluish white to green, yellow, orange and red under excitation by 3650 A. At the same time the colour of the phosphor powders changes from white to grey or black. Similar properties were found in some other crystals containing Ag. The characteristics of these phosphors show some similarities with photographic materials.

539.2 : 535.37

### 4446 INTERPRETATION OF THE FLUORESCENCE SPECTRUM OF NAPHTHALENE. T.N.Bolotnikova.

Optika i Spektrosk., Vol. 7, No. 1, 44-51 (July, 1959). In Russian.

Reports measurements of the fluorescence spectra of frozen solutions of naphthalene at 77°K. The following solvents were used: n-pentane, n-hexane, n-heptane, n-octane, ethyl alcohol and paraffin oil. The sharpness of the spectrum of naphthalene in pentane made it possible to determine precisely the frequency intervals and to distinguish two of these intervals (495 and 927 cm$^{-1}$) from the values of the fully symmetrical frequency intervals of 517 and 940 cm$^{-1}$. It is suggested that the mechanism of the electron-vibrational transition in fluorescence is the same as the absorption mechanism observed in frozen solutions of naphthalene in durene.

A.Tybulewicz

539.2 : 535.37

### 4447 OPTICAL AND SCINTILLATION PROPERTIES OF THE OXYDIAZOLE-SERIES COMPOUNDS.

N.A.Adrova, V.N.Andreev, M.M.Koton, Yu.N.Panov and N.S.Musalev.

Optika i Spektrosk., Vol. 7, No. 1, 128-9 (July, 1959). In Russian.

Reports absorption and luminescence spectra, luminescence quantum yields and scintillation yields of plastic scintillators containing 2-$\alpha$-naphthyl-5-(n-biphenyl)-1,3,4-oxydiazole ($\alpha$-NBD) and 2-phenyl-5-(n-biphenyl)-1,3,4-oxydiazole (PBD). The properties of $\alpha$-NBD and PBD are compared with those of 2,5-diphenyloxydiazole (PPD) and n-terphenyl. The scintillation yields of $\alpha$-NBD and PBD are shown to be considerably higher (~25%) than the scintillation yield of n-terphenyl.

A.Tybulewicz

539.2 : 535.37

### 4448 A QUANTUM-MECHANICAL CALCULATION OF A LUMINESCENCE CENTRE IN KCl:Tl N.N Kristofel'.

Optika i Spektrosk., Vol. 7, No. 1, 78-82 (July, 1959). In Russian.

A quantum-mechanical method (Kristofel 1958) of calculating the adiabatic potentials of luminescence centres in alkali-halide crystal phosphors is used to discuss the excited state and the spectral properties of a luminescence centre in KCl:Tl. Each centre is assumed to consist of activator ions which replace one or more cations at a lattice site. The activator electrons are assumed to interact with local vibrations. The number of ions in one centre is taken to be equal to the number of ions taking part in interactions with local vibrations. It is also assumed that the activator ions interact only with fully symmetrical local vibrations. The agreement between theory and experiment appears to confirm the assumed model.

A.Tybulewicz

539.2 : 535.37

### 4449 SOME OF THE LUMINESCENT PROPERTIES OF AgBr WITH AN ADMIXTURE OF Ag₂S.

J.Frána and F.Jánaček.

Czech. J. Phys., Vol. 9, No. 2, 256 (1959).

AgBr with 0.02 mol. % $Ag_2S$, excited by a high-pressure Hg lamp at −180°C, shows emission peaks at 6450, 6100 and 5350 A. At −110°C there is only one red peak and no green. The decrease of emission by pressure deformation is described, and constants given for the hyperbolic decay characteristics.

S.T.Henderson

539.2 : 535.37

### 4450 LUMINESCENCE OF STILBENE CRYSTALS AT 20°K. A.F.Prikhot'ko and I.Ya.Fugol'.

Optika i Spektrosk., Vol. 7, No. 1, 35-43 (July, 1959). In Russian.

Describes studies of luminescence and absorption of 0.5 $\mu$ to 2 mm thick stilbene monocrystals at 20°K and 293°K (room temperature). The crystals were prepared by sublimation or grown from melt. Luminescence was excited by wavelengths near 310 m$\mu$. Absorption spectra were recorded using a hydrogen lamp and two quartz spectrographs. The number and intensities of the luminescence lines were found to vary from sample to sample. Some of the luminescence lines coincided with absorption lines. The intensities, widths and polarizations of the absorption lines also varied from sample to sample. The luminescence and absorption spectra were found to be strongly affected by annealing at either the liquid-nitrogen temperature (77° K) or at the sublimation temperature (~ 70° C). The results obtained indicated that luminescence of stilbene is closely related to structural defects, produced during crystal growth.

A.Tybulewicz

539.2 : 535.37

### 4451 ENERGY YIELD OF LUMINESCENCE IN $\gamma$-SCINTILLATIONS IN A STILBENE CRYSTAL.

Z.A.Chizhikova.

Optika i Spektrosk., Vol. 7, No. 2, 276-8 (Aug., 1959). In Russian.

The energy yield of $\gamma$-scintillations in stilbene was measured following a technique described by Galanin and Grishin (Abstr. 5173 of 1956), except that collection of light was calculated instead of being measured in a photometric sphere. The yield was deduced from the light energy given out on each separate scintillation: for stilbene it was found to be 2.1 ± 0.3%. Since the $\gamma$-scintillation yield of anthracene is approximately twice as large as that of stilbene, the yield for anthracene may be taken to be 4%, which is twice as high as that reported by Galanin and Grishin.

A.Tybulewicz

539.2 : 535.37

### 4452 EMISSION OF TERBIUM HEXA-ANTIPYRINE TRI-IODIDE.

L.G.Van Uitert, R.R.Soden and R.G.Treuting.

J. appl. Phys., Vol. 30, No. 12, 2017 (Dec., 1959).

Fluorescent and triboluminescent effects were observed with terbium hexa-antipyrene tri-iodide crystals. The fluorescence was stimulated primarily by a 2537 A radiation from a mercury lamp, while the latter effect was sufficiently intense to be observed in daylight by crushing well-formed crystals. The maximum emission intensity was at 5500 A.

I.Cooke

539.2 : 535.37

### 4453 RELATION BETWEEN THE DECREASE OF QUANTUM YIELD AND THE LAW OF EMISSION OF ZINC SILICATE ACTIVATED BY MANGANESE.

H.A.Arduino, J.C.Guerci and A.Levialdi.

C.R. Acad. Sci. (Paris), Vol. 250, No. 5, 831-3 (Feb. 1, 1960). In French.

The phosphor was excited by periodic pulses of 2537 A radiation, and the light output presented on an oscilloscope. Decay curves were derived for various conditions and temperatures up to 100° C.

S.T.Henderson

539.2 : 535.37

### 4454 CRYSTAL STRUCTURE AND ELECTROLUMINESCENCE IN ZnS. D.W.G.Ballentyne.

J. Phys. Chem. Solids, Vol. 10, No. 2-3, 242 (July, 1959).

Electroluminescence appears in ZnS when the Cu content increases to $10^{-3}$ parts by weight, and this coincides with the disappearance of deep traps and the change from hexagonal to cubic structure. Ag replacing Cu produces the same effects above a concentration of $10^{-2}$.

S.T.Henderson

539.2 : 535.37

### 4455 FORMATION AND ACTION OF LOCALIZATION LEVELS IN ZnS:Mn PHOSPHORS. V.L.Levshin and B.D.Ryzhikov.

Optika i Spektrosk., Vol. 4, No. 3, 358-64 (1958). In Russian. English summary: PB 141047T-4, obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

Trapping level measurements were made with ZnS phosphors containing Mn up to 0.1 g/g. Blue emission was obtained up to a Mn concentration of 0.001 g/g. orange emission occurred for concentrations between 0.0002 and 0.03 g/g. Thermal glow curves are given for various Mn concentrations and various wavelengths of exciting light. The change of absorption of ZnS with Mn concentration was measured. The relation between trap depth and probability of excitation is discussed. At low concentrations Mn ions occupy positions close to defects, at higher concentrations Mn ions replace Zn ions at lattice sites.

J.Franks

539.2 : 535.37

### 4456 PHOSPHORESCENCE OF SOLID NITROGEN.

A.M.Pilon.

C. R. Acad. Sci. (Paris), Vol. 249, No. 16, 1492-3 (Oct. 19, 1959). In French.

Preliminary observations are reported upon the effect of high magnetic fields (40 kG) upon the components $\alpha$ (5229 A) and $\alpha'$ (5945 A) (see Abstr. 7484 of 1959), of the luminescence from nitrogen deposited at 4.2° K from a microwave discharge. The principal effect is a decrease in intensity of the spectral features. An apparent rotational structure has been noticed in the main line (5945 A) of the $\alpha'$ feature in some cases. Ten, rather than the commonly reported five, components of the $\alpha'$ feature have been observed (both with and without the field) between 5932 A and 6017 A. Line widths are too great to detect a Zeeman effect.

R.W.Nicholls

539.2 : 535.37

### 4457 VARIATION OF THE ELECTRO-ENHANCEMENT EFFECT WITH THE FREQUENCY OF THE ELECTRIC FIELD. J.Mattler.

C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2051-3 (Nov. 16, 1959). In French.

Measurements of the field enhancement ratio were made on ZnCdS:Mn, Au, Cl phosphors excited by X-rays and $\alpha$-rays for frequencies between 20 and 4000 c/s at various field strengths. The enhancement ratio dropped as the frequency increased.

J.Franks

539.2 : 535.37 : 621.397.331.24

### 4458 PHOTOSENSITIZATION OF PHOSPHOR LAYERS.

I.Bornemann.

Exper. Tech. der Phys., Vol. 7, No. 3, 126-34 (1959). In German.

The photo-resist technique, using an alkali bichromate and a soluble colloid (polyvinyl alcohol), is described in its application to three-colour screens on cathode-ray tubes. Photomicrographs are shown of different stages, some faulty and some successful.

S.T.Henderson

539.2 : 535.37

### 4459 THE TEMPERATURE DEPENDENCE OF $\gamma$-SCINTILLATIONS IN CAESIUM IODIDE CRYSTALS ACTIVATED BY THALLIUM.

S.N.Komnik, V.I.Startsev and Yu.A.Tsirlin.

Optika i Spektrosk., Vol. 4, No. 3, 411-12 (1958). In Russian. English summary: PB 141047T-4 obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington,D.C., U.S.A

The intensity of scintillation under exposure to $Co^{60}$ falls by 0.7% per deg C at 30° C, and at 150° C has decreased to about 20% of its value at 30° C. The measured intensity agrees approximately with the equation $I = A/\{1 + b \exp(-\epsilon/kT)\}$ where $b = 31500$ and $\epsilon = 4.9 \times 10^{-13}$ ergs.

S.T.Henderson

539.2 : 535.37

### 4460 EFFECT OF RADIATIONLESS RECOMBINATION ON SATURATION IN CATHODOLUMINESCENCE.

Yu.M.Popov and V.P.Shabanskii.

Optika i Spektrosk., Vol. 6, No. 6, 769-75 (June, 1959). In Russian.

It is shown that the non-linear portion of the cathodoluminescence yield (saturation effect) occurs at high free electron and hole densities at which radiationless recombination appears. Theoretical predictions of the cathodoluminescence yield and its dependence on the excitation intensity were found to agree with experiment. The energy balance of electrons involved in recombination processes is given and the electron temperature of the phosphor is estimated.

A.Tybulewicz

539.2 : 535.37

### 4461 A COMPARATIVE STUDY OF LIGHT-SUM STORAGE AND TEMPERATURE QUENCHING IN A ZnS:Ag PHOSPHOR EXCITED WITH $\beta$-RAYS AND LIGHT.

V.L.Levshin and V.N.Rebane.

Optika i Spektrosk., Vol. 7, No. 2, 236-40 (Aug., 1959). In Russian.

Reports a study of thermoluminescence and temperature quenching of $ZnS:Ag:MgCl_2$ excited by means of light (3650 A) and $\beta$-rays from $P^{32}$, $Tl^{204}$ and $S^{35}$. For both types of excitation the same system of local levels (indicated by thermoluminescence peaks was obtained. Peculiarities of $\beta$-excitation exhibited both in thermo luminescence and in temperature quenching were found to be entirely due to its low intensity: a 5.7 millicurie $P^{32}$ source delivered energy to the phosphor surface at the rate of about $10^{13}$ eV/ $cm^{-3}$ $sec^{-1}$, which was the equivalent of a 0.003 $\mu W\ cm^{-2}$ light beam.

A.Tybulewicz

539.2 : 535.37

### 4462 TEMPERATURE DEPENDENCE OF SECONDARY PEAK OF ELECTROLUMINESCENCE OF ZnS--Cu. K.Pátek.

Czech. J. Phys., Vol. 9, No. 4, 460-7 (1959).

The temperature and frequency dependences of the secondary peak of the brightness wave were studied. The dependences found show a direct connection with the number and depth of the traps. The influence of a continuously increasing temperature on the secondary peak of electroluminescence of a sample, which has been irradiated beforehand, is found and a description given of a new method of determining trap depths and their number.

539.2 : 535.37

### 4463 REMARKS ON THE THEORY OF ELECTROLUMINESCENCE IN ZnS CRYSTALS. K.Kuchař.

Czech. J. Phys., Vol. 9, No. 6, 679-84 (1959). In German.

Electroluminescence is assumed to depend on tunnelling of electrons through a semiconductor layer on the crystal surface and their subsequent recombination with empty activator centres during the applied voltage cycle. Comparison of theory and experimental results is made for the dependence of emission on applied field strength and frequency and on temperature. G.F.J.Garlick

539.2 : 535.37

### 4464 THERMOLUMINESCENCE OF ZnS SINGLE CRYSTALS.

H.Arbell and A.Halperin.

Phys. Rev., Vol. 117, No. 1, 45-52 (Jan. 1, 1960).

The blue and green components of the glow of ZnS:Cu:Cl crystals were recorded separately. Thermoluminescence-excitation spectra taken for each of the components were found to be identical with the excitation spectra for the blue and green luminescence at steady excitation. Other measurements included the spectral distribution of the glow, saturation effects, effects of infrared radiation, and computation of activation energies. The activation energy for the blue peak was found to be about 0.14 eV, and that for the green — about 0.20 eV. From the shape of the peaks it was concluded that the recombination process is bimolecular in character. Electrical glow curves were also recorded and were found to be similar to the green glow curves. The results are discussed and an energy model is proposed.

539.2 : 535.37

### 4465 EVALUATION OF THERMAL ACTIVATION ENERGIES FROM GLOW CURVES. A.Halperin and A.A.Braner.

Phys. Rev., Vol. 117, No. 2, 408-15 (Jan. 15, 1960).

A new method for the evaluation of thermal activation energies from glow curves of excited crystals is described. Use is made of the symmetry of the glow peak, from which the activation energy is calculated by a simple formula: $E = (q/\delta)kT_g^2$, where $T_g$ is the peak temperature, k is Boltzmann's constant, $\delta$ is the half-width towards the falloff of the glow peak, and g is a factor which can be computed from the shape of the glow peak. Values of $q \leq 1$ were found for monomolecular processes, while $1 \leq q \leq 2$ correspond to bimolecular ones. The method thus enables the type of kinetics to be determined. See also following abstract.

539.2 : 535.37

### 4466 THERMAL ACTIVATION ENERGIES IN NaCl AND KCl CRYSTALS.

A.Halperin, A.A.Braner, A.Ben-Zvi, and N.Kristianpoller.

Phys. Rev., Vol. 117, No. 2, 416-22 (Jan. 15, 1960).

Thermal activation energies were computed from various glow peaks of NaCl and KCl single crystals, using the method described in the preceding abstract. Good agreement was obtained with the results calculated from the initial rise of the glow peaks. Activation energies varied from 0.3 to 1.5 eV for various peaks in the glow curve of NaCl between 150 and 500° K. Similar results were obtained for KCl crystals. The kinetics of the processes was found to be nearly of first order.

539.2 : 535.37

### 4467 AUTOMATIC RECORDING OF A THERMOLUMINESCENCE CURVE. T.Sh.Davitashvili.

Pribory i Tekh. Eksper., 1959, No. 3, 146-7 (May-June). In Russian.

Gives circuit diagrams and brief descriptions of the two channels of a device for parametric recording of luminescence as a function of temperature. The first channel has a photomultiplier and a.c. amplifier, an external source of 40 V, 910 c/s being used to modulate the electron density in the photocathode-diaphragm space. The second channel includes differential thermocouple, mechanical d.c. to a.c. converter, and a.c. amplifier. A photograph shows as an example the curves obtained (with time as parameter) of the luminescence intensity of X-irradiated monocrystalline KCl in the temperature range 0° to 200° C. D.E.Brown

## MAGNETIC PROPERTIES OF SOLIDS

539.2 : 538.2

### 4468 SOME PROBLEMS OF THE THEORY OF THE de HAAS—van ALPHEN EFFECT. G.E.Zil'berman.

Fiz. Metallov. i Metallovedenie, Vol. 7, No. 4, 504-12 (1959). In Russian.

Using previous results (Abstr. 6704 of 1957; 2029 of 1958) the author derives some formulae for the motion of electrons in a magnetic field H with arbitrary types of dispersion. There is a shift of the quasi-classical energy levels proportional to $H^2$. Non-diagonal energy terms are also shifted but in a different way. "Doubling" of electron trajectories is investigated and the results applied to special cases of the de Haas—van Alphen effect. Broadening of electron energy levels in the magnetic field is investigated for special cases including that of closed electron trajectories. A.F.Brown

539.2 : 538.2

### 4469 THE MAGNETIC SUSCEPTIBILITY OF THE ELECTRONS IN SILICON, GERMANIUM AND INDIUM ARSENIDE. D.Geist.

Z. Phys., Vol. 157, No. 3, 335-61 (1959). In German.

In Ge the electrons ($5 \times 10^{16}$ and $6 \times 10^{18}$ cm$^{-3}$) possess at 141 and 297°K a diamagnetic susceptibility which agrees with the effective mass m* determined from cyclotron resonance at 4°K. It follows that the conduction band possesses four minima. From 141 to 297°K m* increases. For Si the electrons ($4 \times 10^{18}$ cm$^{-3}$) show a diamagnetic susceptibility much less than expected from the value of m* obtained from cyclotron resonance at 4°K. This suggests that m* is much smaller at 4°K than 100°K. It is difficult to determine whether there are three or six minima in the conduction band. Electrons in InAs ($5 \times 10^{16}$ to $6 \times 10^{19}$ cm$^{-3}$) possess a susceptibility which at first increases with carrier concentration and then decreases. The conduction band deviates strongly from the simple parabolic form. The magnetic behaviour agrees with theoretical predictions of Stern. C.A.Hogarth

539.2 : 538.2

### 4470 SUPERPARAMAGNETISM.

C.P.Bean and J.D.Livingston.

J. appl. Phys., Supplement to: Vol. 30, No. 4, 120S-129S (April, 1959).

Single domain ferromagnetic particles at elevated temperatures can behave magnetically in a manner analogous to the Langevin paramagnetism of moment-bearing atoms. The main distinction is that the moment of the particle may be $10^5$ times the atomic moment. The experimental and theoretical foundations of this effect are reviewed and indication is made of the applications of this phenomenon. Lastly, attention is drawn to some current problems in this area.

539.2 : 538.2

### 4471 HIGH-TEMPERATURE MAGNETIC SUSCEPTIBILITY OF SINTERED αMnS.

J.J.Banewicz, R.F.Heidelberg and R.Lindsay.

Phys. Rev., Vol. 117, No. 3, 736-7 (Feb. 1, 1960).

The magnetic susceptibility of sintered $\alpha$MnS was measured by a Faraday method at temperatures from 300° to 1244°K (for previous work on the range 90° to 550°K, see Abstr. 5111 of 1958). When the data were fitted by a least squares method to the Weiss—Curie law, $\chi_M = C_M/(T + \theta)$, using only points above 675°K, values of $C_M = 3.94 \pm 0.02$ and $\theta = 397 \pm 6$°K were obtained. Even in this range the $1/\chi$ versus T curve was slightly inflected towards the $1/\chi$ axis so the above values are considered only as establishing upper limits on the constants. It is suggested that the deviation of $C_M$ from the theoretical spin only value of 4.379 be interpreted in terms of a reduced ionic character of the MnS bond.

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### 4472 LOW-TEMPERATURE MAGNETIC REMANENCE, MOLECULAR FIELD, AND APPROACH TO SATURATION OF HOLMIUM METAL. W.E.Henry.

Phys. Rev., Vol. 117, No. 1, 89-92 (Jan. 1, 1960).

Magnetization approaching absolute magnetic saturation was achieved for polycrystalline holmium metal. At 1.3° K and 70 000 G, the magnetic moment is approaching 4.0 Bohr magnetons per atom of holmium in contrast to the 10 Bohr magnetons per atom expected on the basis of the spectroscopically determined quantum numbers. The actual results are explained on the basis of crystalline electric field splitting of the ground term of holmium and application of the

Pauli exclusion principle. In the liquid helium range, there is a pronounced hysteresis; i.e., the moment at 10 000 G is 50% higher in decreasing fields than in increasing fields. The remanence is 0.22 Bohr magneton per atom of holmium at 4.2° K and 0.42 Bohr magneton per atom at 1.3° K. A sample motion technique was used to measure the magnetic moment of the 5 gram sample. The equipment was calibrated with iron and nickel.

539.2 : 538.2

### 4473 TEMPERATURE DEPENDENCE OF THE MAGNETIZATION OF DYSPROSIUM METAL. K.Niira.

Phys. Rev., Vol. 117, No. 1, 129-33 (Jan. 1, 1960).

The experimental fact that the temperature dependence of the saturation magnetic moment of dysprosium metal shows a marked departure from the Bloch $T^{3/2}$ law at low temperatures is interpreted as due to magnetic anisotropy. The calculation is in the spin-wave approximation and gives a result which agrees well with the observed temperature dependence of the magnetization if the magnitude of the magnetic anisotropy is suitably chosen. A discussion on the atomic origin of the magnetic anisotropy is given.

539.2 : 538.2

### 4474 MAGNETIC COUPLING IN CRYSTALLINE COMPOUNDS. A PHENOMENOLOGICAL THEORY OF MAGNETISM IN 3d METALS. E.O.Wollan.

Phys. Rev., Vol. 117, No. 2, 387-401 (Jan. 15, 1960).

Magnetic coupling processes are considered in terms of the orbitals which result from the splitting of the d levels by the crystalline field. It is shown that the antiferromagnetic and ferromagnetic structure properties of many crystalline compounds can be qualitatively accounted for on the basis of indirect coupling processes which depend on the overlap of magnetic cation d orbitals with p orbitals of intervening anions and on the electron spin occupation appropriate to the particular cations involved. The orbital approach has also been used in considering the magnetic properties of the 3d metals and a coupling mechanism has been proposed which is consistent with much of the magnetic data relating to the iron group metals and their alloys.

539.2 : 538.2

### 4475 INTERACTION BETWEEN ELECTRON BEAM AND MAGNET. S.Yamaguchi.

Nuovo Cimento, Vol. 14, No. 1, 248-9 (Oct. 1, 1959).

Describes some observations of the deflection of an electron beam passing through the edge of a magnet. There is a time lag of 1 sec between the initial passage of the beam and the resultant deflection. An explanation is profferred in terms of the positive holes in the d-band of iron producing favourable conditions for resonant interaction between the electrons of parallel spin in the d-band and those of anti-parallel spin in the electron beam.

A.E.I. Research Laboratory

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### 4476 FERROMAGNETISM REPRODUCIBLE AT WILL IN THE REGION OF STOICHIOMETRIC IMPURITY OF NICKEL OXIDE. N.Perakis and G.Parravano.

C.R. Acad. Sci. (Paris), Vol. 250, No. 4, 677-9 (Jan. 25, 1960). In French.

Remanence can be produced in a sample of NiO which departs from stoichiometry by cooling from the Néel temperature in a magnetic field. If x is the excess atomic concentration of oxygen and $\Sigma$ is the remanence in Bohr magnetons, $\Sigma = 0.16x$ for $4 \times 10^{-3} \leq x \leq 3 \times 10^{-3}$.

D.J.Oliver

539.2 : 538.2

### 4477 THE FLUCTUATING FIELD FERROMAGNET AT LOW TEMPERATURES. F.D.Stacey.

Austral. J. Phys., Vol. 11, No. 3, 310-17 (Sept., 1958).

Neel's concept of fluctuating intermolecular field may be ascribed to localized but migratory elementary magnets in ferromagnetics with non-integral Bohr magneton numbers. This concept allows a low temperature ordering of elementary magnets and a variation with temperature of the effective number of nearest neighbours between which exchange interactions occur. This model alone cannot explain the approach to absolute saturation at 0° K of a ferromagnetic, but it modifies the constant of the $T^{3/2}$ law of approach. In the case of ordering by the mutual attraction of parallel elementary magnets, each consisting of a coupled pair of spins (s = 1) the theoretical and experimental values of this constant for nickel are reconciled.

539.2 : 538.2

### 4478 FERROMAGNETIC ANISOTROPY AND ITS QUANTUM MECHANICAL TREATMENT BY MEANS OF A ONE-ELECTRON MODEL. K.Merkle.

Z. Naturforsch., Vol. 14a, No. 11, 938-51 (Nov., 1959) In German.

Calculates $K_1$ for the 3d electrons in nickel defined by wavefunctions of the $E_g$ and $T_{2g}$ type, and treating spin—orbit coupling as a perturbation. The value of $K_1$ is found to depend on $N(E_F)$ and $N'(E_F)$, and the last is estimated from the observed value. The dependence of $K_1$ on temperature and composition in alloys is also discussed.

E.P.Wohlfarth

539.2 : 538.2

### 4479 TEMPERATURE VARIATION OF THE ANISOTROPY CONSTANTS AND SPONTANEOUS MAGNETIZATION OF MAGNETOPLUMBITE. R.Pauthenet and G.Rimet.

C.R. Acad. Sci. (Paris), Vol. 249, No. 19, 1875-7 (Nov. 9, 1959). In French.

The anisotropy constants, $K_1$ and $K_2$ have been determined as a function of temperature from 2.3° K to the Curie temperature, in magnetoplumbite ($6Fe_2O_3 \cdot PbO$) from measurements of magnetic isothermals made with the applied magnetic field perpendicular to the c-axis. Constants obtained are: Curie temperature 725° K saturation moment for $6Fe_2O_3 \cdot PbO = 18.6\ \mu_B$. $K_1$ and $K_2$ both decrease with temperature; $K_1$ always being approximately fifty times $K_2$.

S.A.Ahern

539.2 : 538.2

### 4480 MAGNETIC SUSCEPTIBILITIES OF IRON—CHROMIUM ALLOYS. M.M.Newmann and K.W.H.Stevens.

Proc. Phys. Soc., Vol. 74, Pt 3, 290-6 (Sept., 1959).

Measurements are reported on the magnetic and other properties (electrical resistance and thermal expansion) of alloys of chromium with small quantities of iron. The results show, as expected, that each iron atom carries a moment of $2\beta$, but it is surprising to find that the moments are freely orientable in a matrix of chromium, which is presumably antiferromagnetic. The implications of this are discussed and further experiments are suggested.

539.2 : 538.2

### 4481 THE MAGNETIC SUSCEPTIBILITY OF IRON DITELLURIDE I. J.P.Llewellyn and T.Smith.

Proc. Phys. Soc., Vol. 74, Pt 1, 65-74 (July 1, 1959).

The magnetic susceptibility of three compositions of the ditelluride phase of the Fe—Te system have been measured between 100° and 1200° K. This temperature range can conveniently be divided into three regions: above 700° K the susceptibility variations of all three compositions can be interpreted in terms of the phase diagram, while below 300° K the variations follow the Curie—Weiss law. Between these temperatures the susceptibilities deviate from the Curie—Weiss values and this has been explained in terms of an increasing concentration of defects. A discussion of the bonding in the three compositions has been given by considering the estimated values of the Curie constants. See also following abstract.

539.2 : 538.2

### 4482 THE MAGNETIC SUSCEPTIBILITY OF IRON DITELLURIDE II.

D.M.Finlayson, J.P.Llewellyn and T.Smith.

Proc. Phys. Soc., Vol. 74, Pt 1, 75-80 (July 1, 1959).

The magnetic susceptibility of stoichiometric iron ditelluride has been measured between 15° and 100° K. The material appears to be antiferromagnetic with a Neel temperature at about 85° K. The curve is anomalous in that the susceptibility at 15° K is greater than that at the Néel temperature. This behaviour can be explained by a simple model of an antiferromagnetic containing some non-magnetic ions, provided that the concentration of the latter changes as a result of the ordering process. The susceptibility of samples of $FeTe_{1.95}$ and $FeTe_{2.10}$ is also given.

539.2 : 538.2 : 537.3

### 4483 MAGNETIC SUSCEPTIBILITY AND ELECTRICAL RESISTIVITY OF Au—Mn ALLOYS.

A.Giansoldati, J.O.Linde and G.Borelius.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 46-54 (Sept., 1959).

From the magnetic measurements made on Au—Mn alloys in both the states, ordered and disordered, the magnetic moment $\mu$ of the manganese atoms and the Weiss temperature $\Theta$ of the alloys have been determined. In the temperature range used (90-1020° K), the electrical resistivity of the alloys has also been determined. The $\Theta$ values of the alloys are found to vary regularly with composition, eing positive at low and negative at high manganese concentrations. esistivity versus concentration curves have been obtained in three ifferent states of the alloys, the atomic as well as the magnetic rder being considered. The magnetic and the electrical measureents show a marked dependence of the magnetic transformation oints on the degree of atomic order of a given alloy, the Curie and he Néel points being displaced towards lower temperatures with ecreasing atomic ordering of the alloy.

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### 4484 α-TRANSFORMATION OF IRON SULFIDE SINGLE CRYSTALS. T.Hihara.

. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 215-24 (Dec., 1958).

The magnetic susceptibility and the electrical conductivity of ron sulphide single crystals near the stoichiometric composition ere measured in order to clarify the mechanism of the α-transformaion. On the basis of the Van Vleck theory of antiferromagnetism, the -transformation may be explained by assuming that as the temperaure is increased through the temperature of α-transformation $T_\alpha$, he direction of spins turns from along the c-axis, to in the plane erpendicular to it, and at the same time the exchange interaction ecreases suddenly. The susceptibility above $T_\alpha$ is also accounted or on this model by assuming a twinning or domain structure within he crystal.

539.2 : 538.2

### 4485 THE EFFECT OF HEAT-TREATMENT ON THE MAGNETIC PROPERTIES OF CARBON-STEEL ASTINGS. W.J.Jackson.

. Iron Steel Inst., Vol. 194, Pt I, 29-36 (Jan., 1960).

Magnetization and hysteresis-loop data were obtained for a eries of cast carbon steels, containing 0.10%, 0.14%, 0.19%, 0.24%, nd 0.34% C, in each of the annealed, normalized, and as-cast conitions. The results demonstrated that magnetic permeability was ncreased by progressively decreasing the carbon content from 0.34% o 0.10% and that the magnetic properties of the annealed material were superior to those of the normalized material. In general, magnetic properties of the as-cast material were inferior. Tensile roperties were also measured. For a 0.17% cast carbon steel, optmum magnetic properties for a minimum furnace time were obtained y slowly cooling through the temperature range 750-650°C, and then air cooling, or at higher magnetizing fields only by furnace cooling o 700°C, then air cooling. The former treatment, when compared with full annealing, offers the possibility of economy in furnace time and heat in the case of batch-type furnaces.

539.2 : 538.2 : 621.318.132

### 4486 AN INVESTIGATION OF THE FREQUENCY DEPENDENCE OF THE PERMEABILITY OF SOME Ni—Fe AND Co—Fe ALLOYS IN THE FREQUENCY RANGE $10^5$ - $10^7$ c/s. E.I.Kondorskii and L.G.Smirnova.

Fiz. Metallov i Metallovedenie, Vol. 6, No. 2, 237-46 (1958). In Russian.

The materials studied were Mo-permalloy with small anisotropy and magnetostriction, Armco iron which is distinctly anisotropic, and Co—Fe alloys containing 20, 36, 60 and 72% Co and exhibiting considerable magnetostriction. The process of manufacturing the alloys and their cold-rolling and heat-treatment is described in some detail. Chemical composition is tabulated as is also the electrical and mechanical properties. For this purpose samples were prepared in the form of tape-wound toroids. The measurements were carried out on a Maxwell bridge and are presented as permeability and resistivity v. frequency for each material. In some cases it is possible to point out the indirect confirmation of theory. S.C.Dunn

539.2 : 538.2

### 4487 MAGNETOTHERMAL EFFECTS IN IRON AND SILICON-IRON. L.F.Bates and D.J.Sansom.

Proc. Phys. Soc., Vol. 74, Pt 1, 53-64 (July 1, 1959).

The thermal changes accompanying the magnetization of specimens of iron and 0.5% silicon—iron and of a single crystal of 2.7% silicon-iron were measured by the direct method in fields between ±1000 oersteds. Agreement with the Stoner and Rhodes theory (Abstr. 5572 of 1949) was found for the range 1000 to 20 oersteds. The coefficient a of their notation was measured for each specimen; for the single-crystal specimen the coefficient b was found from a comparison of the theoretical and the experimental magnetization curves taken at two different temperatures. An estimate made of the effect of including the anisotropy coefficient $K_2$ in theoretical calculations showed it to have little effect in the case of iron at room temperature. An alternative, indirect, method of making magnetothermal measurements was devised for use with the single-crystal specimen. In low fields measurements by the direct and indirect methods do not agree and it is not possible to give a reliable account of magnetization processes in these regions.

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### 4488 DIRECT MEASUREMENT OF DOMAIN WALL ENERGY. L.F.Bates and P.F.Davis.

Proc. Phys. Soc., Vol. 74, Pt 2, 170-6 (Aug., 1959).

Attempts have been made to measure the energy of a Bloch domain wall in a Perminvar ring by a modification of a method suggested by Williams and Goertz (Abstr. 4465 of 1952), based on the fact that a cylindrical domain wall within a ring tends to shrink in order to reduce the total energy of the wall.

539.2 : 538.2

### 4489 DOMAIN STRUCTURE OF COBALT WHISKERS. J.Kaczér, R.Gemperle and Z.Hauptman.

Czech. J. Phys., Vol. 9, No. 5, 606-12 (1959).

An experimental investigation was made by the colloid technique, and a new type of domain structure was found. The width of the domains was studied as a function of the thickness of the whisker. This dependence follows a two-thirds power law and does not agree with existing theories which predict a half-power law.

539.2 : 538.2

### 4490 ELECTRON MICROSCOPE OBSERVATION OF WEISS DOMAINS IN THIN FERROMAGNETIC FILMS.

H.Boersch and H.Raith.

Naturwissenschaften, Vol. 46, No. 20, 574 (1959). In German.

Uses a transmission electron microscope of high resolution to observe domains in iron films by means of the Schlieren method. E.P.Wohlfarth

539.2 : 538.2

### 4491 BLOCH WALL ENERGIES IN IRON AND NICKEL. L.Špaček.

Ann. Phys. (Leipzig), Folge 7, Vol. 5, No. 3-4, 217-28 (1960). In German.

539.2 : 538.2

### 4492 THE USE OF POLARIZED NEUTRONS IN DETERMINING THE MAGNETIC SCATTERING BY IRON AND NICKEL. R.Nathans, C.G.Shull, G.Shirane and A.Andresen.

J. Phys. Chem. Solids, Vol. 10, No. 2-3, 138-46 (July, 1959).

The polarized neutron-beam technique is discussed and utilized in determining the magnetic scattering by iron and nickel. Procedures for obtaining and using polarized beams of monochromatic neutrons are outlined, and experimental data are presented on the performance of two polarizing crystals, $Fe_3O_4$ and 92 Co—8 Fe alloy. The reflectivity of neutrons of different polarization states by single crystals of iron and nickel has been studied and used for determining the magnetic scattering amplitudes at various scattering angles. Comparison is then made between the observed magnetic form values and theoretical values derived from calculated 3d wave-functions.

539.2 : 538.2

### 4493 THE MEASUREMENT OF THE MAGNETIZATION OF THIN FILMS. S.Yamaguchi.

Z. phys. Chem. (Leipzig), Vol. 211, No. 5-6, 354-7 (1959). In German.

By comparing electron diffraction patterns for a magnetized nickel and a gold film, the magnetization of the former was measured at saturation and remanence. E.P.Wohlfarth

539.2 : 538.2

### 4494 ON THE INVESTIGATION OF THIN IRON FILMS WITH THE HELP OF THE FARADAY EFFECT.

H.Boersch, M.Lambeck and W.Raith.

Naturwissenschaften, Vol. 46, No. 21, 595-6 (1959). In German.

A comparison of three methods of using the Faraday effect.

(1) Faraday rotation for normal magnetization (magnetization curve).
(2) Faraday rotation for tangential magnetization (hysteresis loop).
(3) Magneto-optical imaging of the surface of the film. Results for a 250 A iron film are presented. A.J.Manuel

539.2 : 538.2

### 4495 THE INNER ATTENUATION OF THIN NICKEL LAYERS IN AN ALTERNATING MAGNETIC FIELD. K Míšek.

Czech. J. Phys., Vol. 9, No. 3, 411-12 (1959). In German.

539.2 : 538.2

### 4496 ON THE FREQUENCY DEPENDENCE OF THE COERCIVITY OF THIN EVAPORATED NICKEL FILMS, MEASURED IN AN ALTERNATING MAGNETIC FIELD.

W.Hellenthal.

Z. Naturforsch., Vol. 14a, No. 12, 1077-8 (Dec., 1959). In German.

An increase in coercivity with frequency is deduced from the longitudinal magnetoresistance changes, in films between 80A and 400A thick, for alternating magnetic fields from 30 c/s to 10 kc/s.

A.J.Manuel

539.2 : 538.2

### 4497 ON THE THEORY OF RELAXATION PROCESSES IN FERRODIELECTRICS AT LOW TEMPERATURES.

A.I.Akhiezer, V.G.Bar'yakhtar and S.V.Peletminskii.

Zh. eksper. teor. Fiz., Vol. 36, No. 1, 216-23 (1959). In Russian.

A theory of relaxation of the magnetic moment of ferrodielectrics is given. It is shown that due to exchange interaction between the spin waves a Bose distribution is first established for spin waves with given nonequilibrium values of the square and projection of the magnetic moment on the axis of preferred magnetization. Because of magnetic interaction and interaction due to the anisotropy energy the equilibrium values of these quantities are gradually attained. The relaxation times are computed.

539.2 : 538.2 : 539.3

TIME DECREASE OF PERMEABILITY IN TRANSFORMER STEEL. See Abstr. 3150

539.2 : 538.2

### 4498 LOW-TEMPERATURE HEAT CAPACITIES AND THERMODYNAMIC PROPERTIES OF ZINC FERRITES. III. EFFECT OF COPPER SUBSTITUTION.

E.F.Westrum, Jr and D.M.Grimes.

J. Phys. Chem. Solids, Vol. 10, No. 2-3, 120-5 (July, 1959).

For Pt II, see Abstr. 9568 (1959). The heat capacities of annealed and quenched samples of $Cu_{0.05}Zn_{0.90}Fe_{2.05}O_4$ have been determined over the range 5-350°K. The Néel temperature is the same as that previously reported for a similar lithium-substituted zinc ferrite. The result is discussed in terms of the sublattice-population and molecular-field coefficients.

539.2 : 538.2

### 4499 EVIDENCE FOR TRIANGULAR MOMENT ARRANGEMENTS IN MO.$Mn_2O_3$. I.S.Jacobs.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 1-11 (Sept., 1959).

Ferrimagnetic spinel-type compounds frequently have lower spontaneous magnetizations than predicted by the simple Néel model in which tetrahedral A-site moments are antiparallel to octahedral B-site moments. Yafet and Kittel (Abstr. 7388 of 1952) suggested triangular moment arrangements, in which the moments on one kind of site subdivide into two groups making angles with each other. A linear increase in net magnetization with field at high field and low temperature is expected for the triangular arrangement, but not for the antiparallel ferrimagnetic one. Such an increase, or differential susceptibility at high fields, is observed on magnetization curves at 4.2°K in pulsed fields up to 140 kOe on compounds of the form MO . $Mn_2O_3$ where M is Mn, Co, Zn or Mg, and mixtures thereof. It is absent in $Fe_3O_4$. These results support a triangular model and enable a direct measurement of the strength of the B–B interaction. The observed composition-dependence of the spontaneous moment and the high-field susceptibility are in approximate agreement with simple molecular field models. Assuming the absence of anisotropy fields exceeding 70 kOe, the spontaneous moment of $Mn_3O_4$ is found to be 1.56 ± 0.04 Bohr magnetons/molecule, with the B-site moments sub-divided into groups at angles. From a comparison with magnetic measurements at other temperatures, it is suggested that the net A-site moment is dominant.

539.2 : 538.2

### 4500 PIEZOMAGNETISM IN $CoF_2$.

T.Moriya.

J. Phys. Chem. Solids, Vol. 11, No. 1-2, 73-7 (Sept., 1959).

It is pointed out that in antiferromagnetic iron-group difluorides, $MnF_2$, $FeF_2$ and $CoF_2$, a linear compression in the ab-plane can produce magnetization along the c-axis. The magnitude of this piezomagnetic moment is evaluated theoretically for $CoF_2$, in which the largest effect is expected. The estimated order of magnitude of the magnetization is a few tenths c.g.s. under a pressure of 100 kg/cm$^2$ along the [110] direction.

539.2 : 538.2

### 4501 MAGNETIC SUSCEPTIBILITY OF AN ANTIFERROMAGNETIC WHOSE MAGNETIC IONS FORM A F.C.C. LATTICE. A.Corciovei.

Rev. de Physique (Bucarest), Vol. 4, No. 2, 221-33 (1959).

The magnetic susceptibility of a f.c.c. antiferromagnetic lattice is calculated according to the method of Holstein and Primakoff. Only nearest neighbour exchange interaction, anisotropy and magnetostatic energy are included in the Hamiltonian and the magnetic ordering is assumed to be of the first kind. A stable solution to this model requires the existence of a finite anisotropy term.

R.Parker

539.2 : 538.2

### 4502 THEORY OF MAGNETISM OF $NiF_2$.

T.Moriya.

Phys. Rev., Vol. 117, No. 3, 635-47 (Feb. 1, 1960).

The magnetic properties of $NiF_2$ are studied theoretically with the use of a spin Hamiltonian approach. It is shown that the anisotropy of the susceptibility above the Neel temperature indicates a spin arrangement below the Neel temperature in which all the spins are perpendicular to the c axis and the angle between the two sublattice magnetizations is a little smaller than $\pi$, giving rise to a small net ferromagnetic moment along the $\langle 100 \rangle$ direction. This model explains the torque data below the Neel temperature quantitatively. The spin wave frequencies and the magnetic resonance frequencies are calculated. There is a low-frequency branch whose lowest frequency ($k = 0$) corresponds to the anisotropy energy in the ab plane. The magnetic resonance is expected at around 170 kMc/s. A recent nuclear magnetic resonance measurement by Shulman (unpublished) seems to support the present model. The spin arrangement below the Neel temperature proposed by Erickson (Abstr. 6132 of 1953) from his neutron diffraction data seems to be neither possible theoretically nor consistent with the other experimental data. Possible structures of domains and domain walls are discuss based on the same model.

## Magnetic Resonances

539.2 : 538.27

### 4503 IONIC DISTRIBUTION AND FERRIMAGNETIC RESONANCE IN MAGNESIUM FERRITE.

H.S.Belson and C.J.Kriessman.

J. appl. Phys., Supplement to: Vol.30, No.4, 170S-171S (April, 1959).

Three different ionic distributions have been achieved in the same magnesium ferrite single crystal sphere by appropriate heat treatment. The magnetic moment, anisotropy constants, g value, and magnetic resonance half-width have been measured as a function of temperature from −200 to + 250°C for the different ionic distributions. The treatments resulted in saturation magnetizations of 1.28, 2.23, and 1.41 Bohr magnetons respectively. At nitrogen temperature $|K_1|$ was observed to be higher for higher values of the magnetization in agreement with Folen and Rado. One finds for the ferri ion cubic field splitting parameter a, the values −0.0104 cm$^{-1}$ for the A site and + 0.0174 cm$^{-1}$ for the B site. The resonance half-width depends on the crystalline direction and was narrower in the hard [100] direction for the original ionic distribution. Successive treatments broadened the half-width in the hard direction while the easy direction [111] remained relatively unchanged. After the treatments the narrower half-width was observed in the easy direction. The room temperature g value of about 2.01 was relatively independent of the ionic distribution. A slight dependence of g value on temperature was observed.

539.2 : 538.27

### 4504 THEORY OF ANTIFERROMAGNETIC RESONANCE.

Yu.M.Seiidov.

Fiz. Metallov i Metallovedenie, Vol. 7, No. 3, 443-5 (1959). In Russian.

The Bloch or Landau–Lifshits equations describing an antiferromagnetic are modified to take account of damping.

A.F.Brown

539.2 : 538.27

### 4505 PARAMAGNETIC RESONANCE.

R.A.Kamper.

Amer. J. Phys., Vol. 28, No. 3, 249-53 (March, 1960).

The basic idea of paramagnetic resonance is presented in terms of a simple classical mechanical model. The model is then elaborated to show how paramagnetic resonance may be used to obtain information about atomic nuclei and the structure of crystals. A typical apparatus with which it may be observed is briefly sketched.

539.2 : 538.27

4506 NUCLEAR POLARIZATION BY ELECTRON PARAMAGNETIC RESONANCE IN PARAMAGNETIC CRYSTALS. M.Odehnal.
Czech. J. Phys., Vol. 9, No. 4, 421-31 (1959).

The possibility of the polarization of nuclei in paramagnetic salts by saturation of electron paramagnetic resonance is theoretically analysed. The proposed method assumes saturation of the "forbidden" transition of the type $\Delta M = \pm 1$, $\Delta m = \pm 1, \pm 2$, for mutually perpendicular external magnetic and high-frequency fields. The analysis is carried out for the case of a large quadrupole moment of the nucleus. The degree of orientation attained is comparable in order of magnitude with Overhauser's method (1954). This method is particularly suitable for the polarization of nuclei of transuranium elements.

539.2 : 538.27

4507 CRYSTAL CONSTITUENT EFFECTS. IV. MAGNETIC RESONANCE AND PARTITION STUDIES ON $Cr^{3+}$ IN $Zn_3La_2(NO_3)_{12}\cdot 24H_2O$. D.P.Devor and R.C.Pastor.
J. chem. Phys., Vol. 31, No. 4, 1145-6 (Oct., 1959).

For Pt III, see Abstr. 11245 (1959). Paramagnetic resonance was performed at X-band and temperatures of 300, 77 and 4.2°K. The crystal field at the two inequivalent, roughly equally populated, sites is axial; the measured values of the parameters in the spin-Hamiltonian at the three temperatures are given. Samples were grown from solutions containing 30, 40 and 50% molar concentration of $Cr^{+++}$, but the quantity of $Cr^{+++}$ incorporated in the crystals was much smaller. For all three solutions the partition coefficient K had the same value of $4.7 \times 10^{-3}$. J.M.Baker

539.2 : 538.27

4508 OPTICAL DETECTION OF PARAMAGNETIC RESONANCE IN AN EXCITED STATE OF $Cr^{3+}$ IN $Al_2O_3$.
S.Geschwind, R.J.Collins and A.L.Schawlow.
Phys. Rev. Letters, Vol. 3, No. 12, 545-8 (Dec. 15, 1959).

See Abstr. 2960 (1960). Paramagnetic resonance has been observed in an excited metastable state of $Cr^{3+}$ in $Al_2O_3$ by a method of optical detection which should have wide applicability to the general problem of studying paramagnetic resonance in excited states of ions in solids. The method makes use of the selective reabsorption in the ground-state Zeeman levels of the fluorescent light from the excited states in solids at very low temperatures. In contrast to the standard optical double resonance techniques in gases, where normally a change in linear or circular polarization is detected along the field direction, this method enables one to observe a change in linear polarization in the much more convenient direction at right angles to the field. A signal arising from approximately $10^{10}$ spins is observed and the line widths, g-values, relaxation times, and magnetic dipole moment matrix element for the transition are measured. J.M.Baker

539.2 : 538.27

4509 OPTICAL DETECTION OF PARAMAGNETIC RESONANCE IN CRYSTALS AT LOW TEMPERATURES.
J.Brassel, S.Geschwind and A.L.Schawlow.
Phys. Rev. Letters, Vol. 3, No. 12, 548-9 (Dec. 15, 1959).

Discusses extensions of the method of detection of magnetic resonance in the fluorescent state which utilizes the selective reabsorption of the components of the fluorescent radiation at low temperatures (see preceding abstract). It is also indicated where the more conventional double resonance techniques may be applied to the study of paramagnetic ions in crystal lattices. In addition, it is pointed out that optical detection of magnetic resonances in the ground state may have some merits of its own. J.M.Baker

539.2 : 538.27

4510 "SPIN-FLIP NARROWING" OF PARAMAGNETIC RESONANCE LINES. J.M.Daniels and H.A.Farach.
Canad. J. Phys., Vol. 38, No. 1, 151-2 (Jan., 1960).

The paramagnetic resonance spectra of copper in (5% Cu 95% Zn) $K_2(SO_4)_2.6\,H_2O$ and (5% Cu 95% Co) $K_2(SO_4)_2.6\,H_2O$ have been studied at room temperature and at 77°K. It is shown, using the results obtained from the copper-cobalt salt, that for paramagnetic salts containing two paramagnetic ions with very different values of $T_1$, the width of the observed resonance line for one component decreases when $T_1$ for the other becomes very short, a situation analogous to motional narrowing in liquids. S.A.Ahern

539.2 : 538.27

4511 ELECTRON-SPIN PARAMAGNETIC RESONANCE STUDIES OF METALLIC LITHIUM IN NEUTRON-IRRADIATED LiF. Y.W.Kim, R.Kaplan and P.J.Bray.
Phys. Rev., Vol. 117, No. 3, 740-1 (Feb. 1, 1960).

The electron-spin paramagnetic resonance (e.s.p.r.) absorption of conduction electrons in lithium metal in neutron-irradiated LiF has been observed. The dependence of the e.s.p.r. line shape and width on the temperature during irradiation and subsequent thermal annealing is discussed. An upper bound is set on the probability for flip of the spin in a collision with the metal surface.

539.2 : 538.27

4512 ELECTRON SPIN–LATTICE RELAXATION IN PHOSPHORUS-DOPED SILICON.
A.Honig and E.Stupp.
Phys. Rev., Vol. 117, No. 1, 69-83 (Jan. 1, 1960).

Electron spin–lattice relaxation in phosphorus-doped silicon was investigated over a magnetic field range of 0 to 11 000 Oe, a temperature range of 1.25° to 4.2°K, and a concentration range of $10^{14}$ to $3 \times 10^{16}$ P/cm$^3$. Three distinct $\tau_S(\Delta m_S = \pm 1, \Delta m_I = 0)$ relaxation mechanisms were identified, and their functional dependences on magnetic field, temperature, and concentration were determined. These mechanisms are characterized as follows: (a) $(1/\tau_S)(H^4,T)$ is concentration independent, and has an $H^4$ and T dependence. At 3000 Oe and 1.25°K, $(1/\tau_S)(H^4,T) = (2.63 \pm 0.10) \times 10^{-5}$ sec$^{-1}$. (b) $(1/\tau_S)(T^7)$ is independent of concentration and magnetic field, and has a $T^7$ dependence. At 2.00°K, $1/\tau_S(T^7) = (1.65 \pm 0.15) \times$ $\times 10^{-4}$ sec$^{-1}$. (c) $(1/\tau_S)$(conc.) depends linearly on concentration for concentrations below $10^{16}$ P/cm$^3$, and has approximately an $H^{-1/2}$ and T dependence. At 3000 Oe and 1.25°K, $1/\tau_S$(conc.) for a $4 \times 10^{15}$ P/cm$^3$ sample is $3.3 \pm 0.4 \times 10^{-4}$ sec$^{-1}$. In addition to these three $\tau_S$ mechanisms, the horizontal relaxation modes $(\Delta m_I = \pm 1, \Delta m_S = 0, \pm 1, \mp 1)$ were investigated. $1/\tau_X(\Delta m_I = \pm 1, \Delta m_S = \mp 1)$ at 2.16°K is independent of concentration and magnetic field, and between 2.16° and 4.2°K, has a $T^{6.5}$ temperature dependence; all of which strongly suggests a dominant Raman process in this temperature region. At 2.16°K, $\tau_X = 3.0 \pm 0.4$ hr. At 1.25°K, the magnetic field dependence of the horizontal modes was measured. The large errors (associated with the very long times involved) make it difficult to ascertain the dominant mechanism here. However, these results are not consistent with a quadratic magnetic field dependence of $1/\tau_X$. At low magnetic fields, concentration dependent $\tau_N(\Delta m_I = \pm 1, \Delta m_S = 0)$ and $\tau_X$ mechanisms arise, due to an admixture of states which allows $1/\tau_S$(conc.) also to induce $1/\tau_N$ and $1/\tau_X$ transitions. When all the preceding mechanisms are properly superposed, their resultant agrees well with the experimental relaxation probabilities, except for a small discrepancy which shows up for dilute samples at 1.25°K. This discrepancy ($\sim 2 \times 10^{-5}$ sec$^{-1}$ at 1.25°K) can be accounted for by introducing another mechanism. There is some indication that this mechanism is associated with the amount of compensation. The theoretical origins of the mechanisms are discussed. A theory is proposed to explain the concentration dependent $\tau_S$ mechanism, according to which rapidly relaxing close pairs of phosphorus atoms, which are few in number, relax the spins of the large number of isolated phosphorus atoms via a spin diffusion process. Experiments supporting this hypothesis are reported.

539.2 : 538.27

4513 SPIN–LATTICE RELAXATION TIMES IN RUBY AT 34.6 kMc/sec. J.H.Pace, D.F.Sampson and J.S.Thorp.
Phys. Rev. Letters, Vol. 4, No. 1, 18-19 (Jan. 1, 1960).

Measurements of spin–lattice relaxation times ($T_1$) have been made in ruby containing a nominal 0.1% Cr at a frequency of 34.6 kMc/s, between 1.4° and 90°K, with the angle between the c-axis and the steady magnetic field equal to 90°, using the pulse saturation technique. The results for the $\Delta M = 1$ transition are in agreement with those of Kikuchi et al. (Abstr. 8349 of 1959) and other unpublished data. For the $\Delta M = 2$ and $\Delta M = 3$ transitions, appreciably different values of $T_1$ were observed at 1.4°K, although values for all transitions approach a common value at 77°K. In the hydrogen-helium temperature range, $T_1$ is approximately inversely proportional to temperature. This relation breaks down in the region 20°-57°K, and above this a more rapid temperature variation is observed.
S.A.Ahern

539.2 : 538.27

### 4514 SPIN RESONANCE OF TRANSITION METALS IN SILICON.

H.H.Woodbury and G.W.Ludwig.

Phys. Rev., Vol. 117, No. 1, 102-8 (Jan. 1, 1960).

Spin resonance measurements are reported for various charge states of four transition metals in silicon, namely for $V^{2+}$, $Cr^{+}$, $Mn^{-}$, $Mn^{2+}$, and $Fe^{0}$. In each case the g tensor and the hyperfine interaction with the impurity nucleus are isotropic. Thus each element exists in an isolated form in silicon and undergoes no distortion from the site of maximum symmetry. The site may either be the substitutional position or the intersiitial position of maximum symmetry in the silicon lattice. For $(V^{51})^{2+}$, $S = \frac{3}{2}$, $A = -42.10$; for $(Cr^{53})^{+}$, $S = \frac{5}{2}$, $a = +30.16$, $A = +10.67$; for $(Mn^{44})^{-}$, $S = 1$, $A = -71.28$; for $(Mn^{55})^{2+}$, $S = \frac{5}{2}$, $a = +19.88$, $A = -53.47$; for $(Fe^{57})^{0}$, $S = 1$, $A = 6.98$, where a is the cubic field splitting parameter, A is the hyperfine interaction of the isotope noted, and both are expressed in units of $10^{-4}$ $cm^{-1}$. Electron-nuclear double resonance was used for accurate measurement of A and for the determination of S. In the case of $Fe^{0}$, the electron spin was checked by noting that the iron line splits into two fine structure components under uniaxial stress. Association of Cr, Mn, and Fe with acceptors in silicon was observed, as well as another charge state of isolated Fe.

539.2 : 538.27

### 4515 PARAMAGNETIC RESONANCE OF $Ti^{3+}$, $Cr^{3+}$, AND $Fe^{3+}$ IN $AlCl_3.6H_2O$

E.Y.Wong.

J. chem. Phys., Vol. 32, No. 2, 598-600 (Feb., 1960).

Magnetic resonance of single crystals of $TiCl_3.6H_2O$, $CrCl_3.6H_2O$, and $FeCl_3.6H_2O$ diluted with $AlCl_3.6H_2O$ was observed. The results in each case were fitted to a spin Hamiltonian.

539.2 : 538.27

### 4516 PARAMAGNETIC RESONANCE OF $Yb^{3+}$ IN YTTRIUM GALLIUM GARNET.

D.Boakes, G.Garton, D.Ryan and W.P.Wolf.

Proc. Phys. Soc., Vol. 74, Pt 5, 663-4 (Nov., 1959).

Paramagnetic resonance has been observed in crystals of $Y_3Ga_5O_{12}$ containing approximately 1% $Yb^{3+}$. Since the structure of this compound is very similar to that of the rare earth iron garnets, the results are of interest in connection with the magnetic properties of $Yb_3Ga_5O_{12}$, $Yb_3Fe_5O_{12}$, and the effects of rare earth impurities in $Y_3Fe_5O_{12}$. The crystals were grown from a PbO flux, and the paramagnetic resonance measurements were made at 4, 20 and 90° K and at 9 kMc/s. Six magnetically inequivalent rare earth ions are observed with identical slightly anisotropic g-tensors except for rotations. In addition to g-values some details are given on relaxation times and hyperfine structure of odd Yb isotopes. J.M.Baker

539.2 : 538.27

### 4517 MAGNETIC PROPERTIES OF RARE EARTH IONS IN GARNETS.

W.P.Wolf.

Proc. Phys. Soc., Vol. 74, Pt 5, 665-7 (Nov., 1959).

The magnetic properties of $Yb_3Ga_5O_{12}$, $Yb_3Fe_5O_{12}$ and $Y_3Fe_5O_{12}$ with small quantities of rare earth impurities are discussed. From the g-values measured by Boakes et al.(see preceding abstract), the susceptibility and saturation magnetization to be expected in pure $Yb_3Ga_5O_{12}$ are calculated directly. The discussion is generalized to be applied to other rare earth ions and in particular the anisotropy energy is calculated. It is shown that small quantities of rare earth impurity could produce a large anisotropy in yttrium iron garnet. J.M.Baker

539.2 : 538.27

### 4518 ON THE POWER TRANSFER BETWEEN PARAMAGNETIC SPINS AND CRYSTAL LATTICE. IA.

B.Bölger.

Proc. K. Ned. Akad. Wetensch. B, Vol. 62, No. 5, 315-28 (1959).

The theory of paramagnetic resonance and relaxation in crystals containing ions from the iron transition group is treated in detail. The treatment is restricted to materials in which the effect of the crystal field is small compared with that of Coulomb interactions of the electrons with each other and with the nucleus, allowing the selfconsistent field method to be used to describe the ionic wavefunctions. The well-known procedure for obtaining the magnetic energy levels of chromium-doped potassium cobalticyanide is outlined and the results presented for several orientations in the form of conventional energy level diagrams, and in the form of a rotation diagram. The observed spin-lattice relaxation phenomena are discussed in terms of both the Bloch macroscopic approach and a more fundamental microscopic approach using time dependent perturbation theory. The occurrence of the observed line breadth is also discussed in both classical and quantum mechanical terms. The powe transfer between paramagnetic spins and the crystal lattice is deal with theoretically and experimentally in Pts IB and II respectively. (See following abstracts). S.A.Ahe

539.2 : 538.

### 4519 ON THE POWER TRANSFER BETWEEN PARAMAGNETIC SPINS AND CRYSTAL LATTICE. IB.

B.Bölger.

Proc. K. Ned. Akad. Wetensch B, Vol. 62, No. 5, 329-47 (1959).

The different mechanisms proposed for energy transfer betwe a spin system and its environment are reviewed. As in Pt IA the discussion is limited to non-conducting ionic crystals. S.A.Aher

538.56 : 538.27 : 539.

### OPERATION AND CONSTRUCTION OF 1.42 kMc/s POTASSIU COBALTCYANIDE THREE-LEVEL MASER. See Abstr. 4520

539.2 : 538.27 : 538.5

### 4520 ON THE POWER TRANSFER BETWEEN PARAMAGNETIC SPINS AND CRYSTAL LATTICE. II. EXPERIMENTAL METHODS AND TECHNIQUES.

B.Bölger.

Proc. K. Ned. Akad. Wetensch. B, Vol. 62, No. 5, 348-65 (1959).

The experimental microwave techniques used for measuring th energy transfer between the spin system and its surroundings are briefly reviewed. The apparatus and measurements required for the power saturation method are described in detail. An apparatus for measuring relaxation rates by the pulse saturation method is described, similar in principle to that constructed by Bowers and Mims (Abstr. 13422 of 1959), but different in that the population differences of pairs of levels other than the pair saturated can be measured. Experiments using a sensing frequency of 1.42 kMc/s with the saturating power applied at 4 and 10 kMc/s, have been ma in connection with the construction of a three-level maser to ampli at 1.42 kMc/s. The principle of operation, and method of growth, of chromium-doped potassium cobalticyanide crystals for this mas are described. S.A.Ahe

539.2 : 538.2

### 4521 CROSS RELAXATION IN LiF.

P.S.Pershan.

Phys. Rev., Vol. 117, No. 1, 109-16 (Jan. 1, 1960).

A combined experimental and theoretical study was made. In agreement with theory, the cross-relaxation time $T_{21}$ is observed t be strongly anisotropic and field dependent; at 51.7 G it goes from 0.025 sec in the [100] direction to 7 sec in the [111] direction. A frequency distribution function analogous to the line shapes for magnetic absorption is measured down to $10^{-4}$ times the maximum value; for most orientations a Gaussian is an excellent approximation to it.

539.2 : 538.2

### 4522 EXCHANGE EFFECTS IN ALKALI OZONATES.

S.A.Marshall and D.O.Van Ostenburg.

Phys. Rev., Vol. 117, No. 3, 712-13 (Feb. 1, 1960).

Resonance absorption was observed in polycrystalline samples of potassium and caesium ozonate. The absorptions are characterized by nearly free electron spin g values with line widths ranging from 26 to 49 Oe. Analysis of line shapes based on the Anderson—Weiss model for exchange interaction between equivalent magnetic ions and calculations of line shape moment ratios based on the Van Vleck theory (Abstr. 949 of 1949), strongly suggest exchange interaction narrowing. Values of exchange frequencies for $KO_3$ and $CsO$ are estimated to be 6 × $10^{11}$ and 3 × $10^{11}$ rad $sec^{-1}$, respectively.

539.2 : 538.2

### 4523 NUCLEAR MAGNETIC RESONANCE IN SOLIDS.

E.R.Andrew.

Brit. J. appl. Phys., Vol. 10, No. 10, 431-7 (Oct., 1959).

The basic principles of nuclear magnetic resonance are discus in elementary terms and an outline is given of the apparatus needed to detect the phenomenon. After brief reference to other uses, the application of nuclear magnetic resonance to solids is discussed in more detail. An account is given of the various interactions which generate the resonance spectrum and of associated spin-lattice relaxation mechanisms.

539.2 : 538.27

### 4524 [NUCLEAR] RELAXATION TIME AND DYNAMIC POLARIZATION TIME IN THE PRESENCE OF SPIN DIFFUSION.

J.M.Winter.

R. Acad. Sci. (Paris), Vol. 249, No. 21, 2192-4 (Nov. 23, 1959).
French.

The theoretical frequency dependence of the nuclear relaxation e in a solid containing a small amount of a paramagnetic impurity, ing into account spin diffusion, was verified for $F^{19}$ in LiF. It is nted out that spin diffusion is also important in the establishment dynamic polarization of nuclei in such solids. E.F.W.Seymour

539.2 : 538.27

### 4525 THE KNIGHT SHIFT OF IMPURITIES IN METALS.

E.Daniel.

Phys. Chem. Solids, Vol. 10, No. 2-3, 174-86 (July, 1959).
French.

Some simplifying assumptions made by Knight to explain the ight shift of impurities in metals have been justified by a theor- cal study. It is shown that one can neglect the polarization of the nductive electrons by the nucleus of an impurity atom; there is o a nearly constant ratio between the wave-function at the bottom the conduction band and the corresponding function for a free m. The departure of measurements from Knight's empirical rmula is often small and of the same order of magnitude as the rors due to the approximation used.

539.2 : 538.27

### 4526 THE KNIGHT SHIFT IN ALLOYS.

A.Blandin and E.Daniel.

Phys. Chem. Solids, Vol. 10, No. 2-3, 126-37 (July, 1959).
French.

The dissolving in a metal of atoms of different type or valence an those of the solvent produces oscillations of electronic density ound each dissolved atom. It is shown that this phenomenon can plain the variations in the Knight shift of the matrix. This ex- anation accounts equally well for the considerable observed roadening of the resonance lines. In agreement with experiment, is found that at low concentrations the relative variation of the ight shift is proportional to the concentration of dissolved atoms, ereas the broadening of the lines increases as the square of the ncentration. The same theory accounts for analogous effects served in liquid alloys of alkali metals. The influence is studied transition metal impurities.

539.2 : 538.27

### 4527 THE INFLUENCE OF LATTICE DEFORMATIONS ON THE NUCLEAR MAGNETIC RESONANCE OF METALLIC OPPER.

A.Averbuch, F.de Bergevin and W.Müller-Warmuth.

R. Acad. Sci. (Paris), Vol. 249, No. 22, 2315-17 (Nov. 30, 1959).
French.

Measurements of the nuclear resonance line and of the shape of e X-ray lines have enabled the influence of distortions on the ectric field gradients seen by nuclei to be determined. The results ow that the effect of strain is small compared with the effect of npurities which act principally by the displacement of charge.
D.J.Oliver

539.2 : 538.27

### 4528 SOME EXPERIMENTS ON THE SHAPES OF RESONANCE LINES IN A RIGID LATTICE.

.Abragam and J.M.Winter.

.R. Acad. Sci. (Paris), Vol. 249, No. 17, 1633-4 (Oct. 28, 1959).
n French.

Nuclear resonance signals from the spins of $K^{39}$ and $Ag^{109}$ were bserved in crystals of KF and AgF. The line width was much maller than one would expect from a calculation of the second moment. This narrowing is produced by frequent reversals of the luorine nuclear spins whose nuclear moment is twenty times larger han those of K or Ag. This gives lines with a Lorentzian shape whose width at half intensity is much less than the second moment.
J.M.Baker

539.2 : 538.27

### 4529 NUCLEAR MAGNETIC RESONANCE OF $F^{19}$ IN TEFLON IRRADIATED WITH NEUTRONS.

.Burget and J.Šácha.

zech. J. Phys., Vol. 9, No. 6, 749-50 (1959).

A neutron dose of $10^{12}$ $cm^{-2}sec^{-1}$ for five hours broadens the $F^{19}$ esonance at room temperature in polytetrafluoroethylene by a actor of 1.5.
J.G.Powles

539.2 : 538.27 : 532.7

### 4530 NUCLEAR RESONANCE IN SOLID AND LIQUID METALS: A COMPARISON OF ELECTRONIC STRUCTURES.

W.D.Knight, A.G.Berger and V.Heine.

Ann. Phys. (New York), Vol. 8, No. 2, 173-93 (Oct., 1959).

The electronic structures of ten solid and liquid metals (Li, Na, Rb, Cs, Hg, Al, Ga, In, Sn, Bi) are investigated experimentally and theoretically, and the results of recent nuclear resonance measurements are correlated with already published data concerning magnetic susceptibility, electrical conductivity and atomic arrangement. It is concluded that the electronic structure of each of the metals investigated, with the notable exceptions of Bi and Ga, does not change appreciably at the melting point. Moreover, in Ga and Bi there is a correlation between a change in the electronic structure and structural rearrangements of neighbouring atoms at short range; the other metals considered show neither sort of change. A principal conclusion is that a liquid metal possesses a band structure which is very like that of its solid, provided that short-range structure is not altered during melting. Included are hitherto unpublished values for the nuclear magnetic resonance line shifts in liquid Al, Sn, In, and Bi, and the nuclear spin relaxation times in solid and liquid Ga. The n.m.r. shifts in solid and liquid Al are equal within experimental error. The same is true for Sn. This is in agreement with published results on the alkali metals and Hg, where the corresponding changes are known to be small, suggesting that the electronic structures of the respective solids and liquids are the same. The large quadrupole coupling in Ga, In, and Bi prevents observation of the n.m.r. in the solid state. However, the value of the n.m.r. shift in liquid In is consistent with the values of the hyperfine coupling constant and the electronic specific heat at low temperatures, a situation which is true for most of the other metals. Ga and Bi are the exceptions for which the n.m.r. shift in liquids is much larger than the hyperfine and low-temperature data would lead one to expect. This is taken as evidence for a reduced density of states at the Fermi surface in solid Ga and Bi. Confirmation is provided by the fact that the nuclear spin relaxation time of Ga increases sharply when the metal freezes. The measurement of relaxation in solid Ga is significant because the nuclear quadrupole resonance is directly observed and the relaxation process of of the same type, so that a change in its magnitude may also be related to a density of states.

539.2 : 538.27

### 4531 NUCLEAR MAGNETIC RESONANCE OF RbBr.

J.Itoh and Y.Yamagata.

J. Phys. Soc. Japan, Vol. 14, No. 2, 225 (Feb., 1959).

This work is part of a programme of n.m.r. in alkali halides having alkali and halide ions of similar electronic configuration, for which comparison with the theories is possible with less ambiguity. At room temperature the measured quantities were $T_1(Rb^{87}) = 0.27$ sec, $T_1(Br^{81}) = 0.16$ sec, $\sigma(Rb) = 1.6 \times 10^{-4}$, $\sigma(Br) = 1.05 \times 10^{-4}$. Van Kranendonk's theory (Abstr. 2300 of 1955), in which only the electrostatic effect of charges outside the ion core is taken into account, fits the results better than a covalency theory. Only the $\frac{1}{2}$ to $-\frac{1}{2}$ transitions are seen, the others presumably being smeared out by random quadrupole effects. These experimental results show that there seems to be no substantial difference between the n.m.r. of Rb and Br in RbBr crystals.
J.M.Baker

539.2 : 538.27

### 4532 CHLORINE NUCLEAR SPIN-LATTICE RELAXATION TIME IN SOLID SODIUM CHLORATE AND p-DICHLOROBENZENE.

P.A.Bender, D.A.Jennings and W.H.Tanttila.

J. chem. Phys., Vol. 32, No. 2, 499-502 (Feb., 1960).

The temperature dependence of the chlorine nuclear spin—lattice relaxation time between the pure quadrupole levels was measured as a function of temperature in sodium chlorate and paradichlorobenzene. The results are compared with Chang's theory and found to be in good agreement. The Debye temperatures necessary to establish a fit with Chang's theory are 200°K and 90°K for sodium chlorate and paradichlorobenzene, respectively. The measurements were made in the temperature interval 300-10°K.

539.2 : 538.27

### 4533 NUCLEAR RELAXATION IN KI AT LIQUID HELIUM TEMPERATURES.

S.M.Day and C.F.Squire.

J. chem Phys., Vol. 31, No. 4, 1127-8 (Oct., 1959).

The exponential growth of nuclear polarization of $I^{127}$ in a single crystal of KI at temperatures of 1.5 to 4°K was observed by n.m.r. and two different time constants were obtained depending upon the initial conditions. Starting with thermal equilibrium in zero field and then turning on the field gave $T_1 = 560$ minutes; starting by thoroughly saturating the nuclear resonance absorption gives $T_1 = 213$ minutes, and a lower final polarization than in the first case. Such effects do not occur at $20^\circ$K. Some results are given on the temperature and field dependence of these effects, and there is a brief discussion of a possible reason for the effect.

J.M.Baker

539.2 : 538.27

### 4534 DYNAMIC POLARIZATION OF THE PROTONS IN A FREE RADICAL BY SATURATION OF THE ELECTRON RESONANCE.

You-Hing Tchao and J.Hervé.

C.R. Acad. Sci. (Paris), Vol. 250, No. 4, 700-2 (Jan. 25, 1960). In French.

Proton magnetic resonance at 14 Mc/s in pure diphenylpicrylhydrazyl (DPPH) with intense irradiation of the electron resonance. Up to 3 W an Overhauser effect is observed, and then an emission line as well up to 15 W with enhancement 120. Interpretation is based on work by Winter (1958) and Gutowsky et al. (Abstr. 8361 of 1959).

J.G.Powles

539.2 : 538.27

### 4535 NUCLEAR MAGNETIC RESONANCE OF PROTONS IN CHABAZITE.

P.Averbuch, P.Ducros and X.Paré.

C.R. Acad. Sci. (Paris), Vol. 250, No. 2, 322-4 (Jan. 11, 1960). In French.

The resonance from water molecules in a single crystal of chabazite consists of a doublet of separation dependent on crystal orientation and on water concentration. The spectrum is interpreted in terms of rapid rotation of the water molecules about preferred axes in the crystal.

E.F.W.Seymour

539.2 : 538.27

### 4536 PROTON MAGNETIC RESONANCE STUDY OF LITHIUM SULFATE MONOHYDRATE.

J.W.McGrath, A.A.Silvidi and J.C.Carroll.

J. chem. Phys., Vol. 31, No. 6, 1444-9 (Dec., 1959).

An extended proton magnetic resonance study of $Li_2SO_4.H_2O$ is presented. An oddity in the resulting Pake curves appears. Some of the curves show a shift so that they are described by equations of the form,

$$\Delta H = 2\alpha[3\cos^2(\phi + \phi_0)\cos^2\delta - 1] + \text{constant shift.}$$

There are two orientations of the hydrated water molecule. For these the direction angles of the proton—proton axes with respect to the crystallographic a, b, and c axes are, respectively, $\alpha_0 = 97^\circ$, $\beta_0 = 45^\circ$, $\gamma_0 = 48^\circ$, and $\alpha_0 = 74^\circ$, $\beta_0 = 38^\circ$, $\gamma_0 = 127^\circ$. Apparently the hydrogens bond $O_5$— —H—$O_5$—H— —$O_1$, where $O_5$ are neighbouring water oxygens and $O_1$ is a sulphate oxygen. Several possible origins of the shifts in the Pake curves are discussed with limited success. An adequate theoretical explanation is lacking.

539.2 : 538.27

### 4537 N. M. R. STUDY IN ROCHELLE SALT.

R.Blinc and A.Prelesnik.

J. chem. Phys., Vol. 32, No. 2, 387-8 (Feb., 1960).

The angular dependence of the proton magnetic resonance absorption of a Rochelle salt single crystal was measured. The experimental second moments are compared with the theoretical curves, as calculated for the structures proposed so far. Lösche's model was found to reproduce the qualitative form of the angular dependence, whereas the other structures gave no agreement at all. The occurence of transitions in the proton magnetic absorption line widths at +24° C and below −20° C demonstrates that the assumption of protonic motion, upon which the dynamic theories of ferroelectricity in Rochelle salt are based, is essentially correct.

539.2 : 538.27

### 4538 NUCLEAR QUADRUPOLE RESONANCE OF BROMINE AND IODINE IN MERCURIC BROMIDE AND POTASSIUM TETRAIODOMERCURATE.

D.Nakamura, Y.Uehara, Y.Kurita and M.Kubo.

J. chem. Phys., Vol. 31, No. 5, 1433-4 (Nov., 1959).

$Br^{79}$ and $Br^{81}$ in solid $HgBr_2$ each give a close doublet, suggesting that the two bromine neighbours of a mercury atom have nonequivalent surroundings. Three lines observed in solid $K_2HgI_4$ are ascribed to $I^{127}$.

E.F.W.Seymour

539.2 : 538.27

### 4539 NUCLEAR QUADRUPOLE RESONANCES USING IMPURITY MOLECULES AS PROBES.

R.Baer and C.Dean.

J. chem. Phys., Vol. 31, No. 6, 1690-1 (Dec., 1959).

The $Cl^{35}$ resonance frequencies in p-dichlorobenzene present as a few percent impurity in several solid compounds differ slightly fr that in pure dichlorobenzene. The shifts may be of use in studying solvent behaviour such as phase changes.

E.F.W.Seymou

539.2 : 538.2

### 4540 TEMPERATURE DEPENDENCE OF THE CHLORINE PURE QUADRUPOLE RESONANCE FREQUENCY IN MOLECULAR CRYSTALS.

H.S.Gutowsky and D.W.McCall.

J. chem. Phys., Vol. 32, No. 2, 548-52 (Feb., 1960).

The $Cl^{35}$ pure quadrupole resonance frequency was observed in polycrystalline $CH_2Cl_2$, $CHCl_3$, $CCl_4$, $(CH_3)_3CCl$, and $CH_3CCl_3$ at temperatures of $77^\circ$ K and above. In all cases, the resonance frequency decreases at higher temperatures, in qualitative agreement with Bayer's theory for the torsional motions of the molecule However, a quantitative comparison of the theory with experiment, including Livingston's results at 4 and $20^\circ$ K, reveals significant discrepancies which are discussed and attributed mainly to the decrease in torsional frequencies at higher temperatures. The resonance was found to "fade out" at temperatures below the transition points in those solids, $CCl_4$, $(CH_3)_3CCl$, and $CH_3CCl_3$, where internal or molecular reorientations are known to occur. In the other compounds the resonance was observable up to the melting point. The origin of this phenomenon is discussed briefly.

539.2 : 538.27

### 4541 NUCLEAR QUADRUPOLE COUPLING IN CHLORITE IRON.

J.L.Ragle.

J. chem. Phys., Vol. 32, No. 2, 403-5 (Fe., 1960).

Chlorine pure quadrupole spectra were observed in silver chlorite and sodium chlorite at room temperature. The observed coupling constant of 108.16 Mc/s for silver chlorite is discussed in ter of a simple model of the electronic structure, in which the magnitud of the apparent coupling constant may be understood as resulting from a highly asymmetric field gradient ellipsoid and from residual positive charge on the chlorine atom.

## MECHANICAL PROPERTIES OF SOLIDS

539.

### 4542 CONDENSED THERMODYNAMIC THEORY OF LINEAR ELASTICITY.

M.Roy.

Ingen.-Arch., Vol. 28, 277-80 (1959). In French.

On the main assumption that a free-energy function exists in an elastic body in which no irreversible processes occur, the usual equations of motion, stress boundary conditions, and stress-strain relations for small strains are all derived concisely by considering a general virtual displacement.

J.G.Oldroyd

539.3

### 4543 A CONTRIBUTION TO THE STABILITY CRITERIA OF ELASTICITY THEORY.

U.Wegner.

Ingen.-Arch., Vol. 28, 357-9 (1959). In German.

A parallel exists between the equations for a "dangerous" set of displacements associated with the onset of instability and those representing the movement of a wave front across which there is a discontinuity of acceleration.

J.G.Oldroyd

539.3 : 530.12

### THEORY OF ELASTICITY IN GENERAL RELATIVITY.

See Abstr. 3445

539.3

### 4544 APPLICATION OF THE CALCULATION OF DIRECTIONAL ORDER IN POLYCRYSTALS.

F.Gallissot and R.Vergne.

C.R. Acad. Sci. (Paris), Vol. 249, No. 5, 674-6 (Aug. 3, 1959). In French.

A method already described [C.R. Acad. Sci. (Paris), Vol. 248, No. 5, 703 (Feb. 2, 1959)] is used to calculate the elastic energy of either tensile or torsional strain in the case of a polycrystalline wire of a cubic binary solid solution.

A.R.Stokes

539.3

### 4545 MECHANICAL PROPERTIES OF IRRADIATED SOLIDS. F.A.Levi.

ovo Cimento Suppl., Vol. 12, No. 2, 124-294 (1959). In Italian.

A very extended comprehensive review (170 pages, 693 refer- ces). After some general considerations on radiation damage, nealing and experimental techniques, the various mechanical prop- ties of metals and alloys affected by radiation are discussed; ecial chapters are devoted to uranium and graphite. Work on ic and covalent crystals and on glasses is also included. An pendix deals briefly with recent papers up to the beginning of 1959. special tables summarize all the experimental results.

L.Pincherle

539.3

### 4546 MEASUREMENT OF THE TENSILE STRENGTH OF BRITTLE MATERIALS. R.Berenbaum and I.Brodie.

rit. J. appl. Phys., Vol. 10, No. 6, 281-7 (June, 1959).

Three alternative methods for measuring the tensile strengths brittle materials are investigated and compared with the conven- onal pull method. These are a bending test, an indentation test and test in which disks are compressed diametrally. Experiments on laster of Paris, coal and cement show that, apart from the bending est, the methods give results in reasonable agreement. The ben- ng test, however, is liable to give considerably different results, nd it is shown that this can be attributed to its sensitivity to surface onditions.

539.3

### 4547 THE MEASUREMENT OF THE ELASTIC COEFFICIENTS OF MATERIALS. A.Kammerer.

.R. Acad. Sci. (Paris), Vol. 249, No. 19, 1861-3 (Nov. 9, 1959). French.

The material is in cylindrical form and is a reasonably tight fit in steel tube which is pushed over the central portion. The overall ngth of the specimen is 21 cm and the tube covers the central 5 cm ngth of a specimen 1 cm in diameter. The specimen is tested in ompression. Overall changes of length are determined by dial gauges. orking between the platens of the testing machine while changes in e circumference of the tube are measured by resistance strain auges; similar gauges are used to measure the logitudinal strain long the end portions of the test piece where there is no steel tube. he modulus of elasticity and Poisson's ratio of the specimen are educed from the strain data. The method is only suitable for mat- rials which exhibit large strains. The results show how the moduli ary with the constraint, and, at very high compressive forces, some aterials behave as liquids having nearly zero elastic modulus and Poisson's ratio which tends towards 0.5

A.C.Whiffin

539.3

### 4548 TENSILE TESTING MACHINE FOR MICROSCOPIC SPECIMENS. D.M.Marsh.

. sci. Instrum , Vol. 36, No. 4, 165-9 (April, 1959).

The problems of the mechanical testing of whiskers and thin ilms having gauge lengths down to 0.2 mm and cross-sections as ow as $8 \times 10^{-7}$ mm$^2$ are discussed. A machine is described which ives load-strain curves for such specimens with minimum load ncrements of 0.5 mg f and with extension readings repeatable to .019 μ. A torsion balance applies and measures the load and the strain is obtained by a null method using a marker and a special optical arrangement in a projection microscope. A number of special design features are incorporated to ensure high stability.

539.3

### 4549 APPARATUS FOR THE MEASUREMENT OF INTERNAL FRICTION AND DYNAMIC YOUNG'S MODULUS AT KILOCYCLE FREQUENCIES. E.W.Dickson and H.Strauch.

J. sci. Instrum., Vol. 36, No. 10, 425-8 (Oct., 1959).

Electrostatic transducers are used to excite and detect vibra- tions in a rod specimen clamped at its mid-point. The electronic circuit forms a regenerative loop in which oscillations occur at the resonance frequency of the specimen. A method of calculating the amplitude of the specimen oscillations is given. Measurements of the internal friction and dynamic Young's modulus, which can be made as a function of strain amplitude and temperature up to 500° C, are illustrated by some preliminary observations on beryllium.

539.3

### 4550 DESIGN FOR AN AUTOGRAPHICALLY RECORDING TENSILE MACHINE. M.A.Adams.

J. sci. Instrum.,Vol. 36, No.10, 444-6 (Oct., 1959).

An improved "hard" type tensile machine is described, designed primarily for metallurgical usage. Compactness and mechanical simplicity are combined with maximum accessibility of the load measuring device and specimen, and the load is measured with an electro-mechanical dynamometer which is easily adapted into a system for autographically recording the load-elongation curve. The machine should be particularly useful for dry-box or hot-cell work.

539.3 : 620.172.22

### 4551 RESISTANCE STRAIN GAUGES OF LOW TEMPERATURE SENSITIVITY. G.R.Higson.

J. sci. Instrum., Vol. 36, No. 4, 157-9 (April, 1959).

Strain gauges manufactured from a series combination of Nichrome and Advance wires may be used in quarter-bridge circuits to measure static strains where the temperature is slowly varying. The average temperature drift corresponds to 20 lb/in$^2$ × deg C on steel and 2.5 lb/in$^2$ × deg C on dural and the sensitivity drop is less than 5% up to 250° C. When used in a full-bridge circuit the drift should be negligible.

539.3

### 4552 A MUTUAL CONNECTION BETWEEN IMPRESSION HARDNESS AND NORMAL ELASTICITY MODULUS OF TITANIUM ALLOYS ON INCREASE OF TEMPERATURE.

S.G.Fedotov and V.S.Mikheev.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 5, 933-6 (Oct. 11, 1959). In Russian.

Measurements up to 1000° are reported for modulus of elasticity (E), measured by a resonance method, and Vickers hardness H for a 5-component Ti alloy containing Cr, Fe, Si, and B and for a series of 6-component Ti alloys containing varying quantities of Al. Graphs are given showing the variation of E and H with temperature. Earlier results for a number of pure metals are reproduced as graphs of E versus H at 20, 500 and 800°.

R.F.S.Hearmon

539.3

### 4553 ELASTIC MODULUS OF ISOTOPICALLY-CONCENTRATED LITHIUM.

V.M.Robertson and D.J.Montgomery.

Phys. Rev., Vol. 117, No. 2, 440-2 (Jan. 15, 1960).

The effect of isotopic mass on elastic properties of solids was studied by measuring the elastic modulus of isotopically-concentrated polycrystalline specimens of metallic lithium at 25° C. The elastic modulus of lithium-6 (96.1% $Li^6$, 3.9% $Li^7$) was found to be $(7.93 \pm 0.21) \times 10^{10}$ dynes/cm$^2$, and that of lithium-7 (7.5% $Li^6$, 92.5% $Li^7$) $(7.98 \pm 0.33) \times 10^{10}$ dynes/cm$^2$. Within the limits of precision of the experiments, the values do not differ. It is concluded that isotopic mass has no effect on static elastic properties other than that arising from the change in lattice constants.

539.3

### 4554 THE STRENGTH OF ALUMINIUM SILVER ALLOYS. A.Kelly.

Phil. Mag. (Eighth Ser.), Vol. 3, 1472-4 (Dec., 1956).

A discussion on the strength of aluminium silver alloys, with an analysis of the hardening mechanism based on the passage of a dislocation through zones consisting of spherical clusters of atoms with a high concentration of silver surrounded by a spherical shell rich in aluminium atoms. The lattice strains are assumed to be small.

P.G.Morgan

539.3

### 4555 STRENGTH OF GLASS FIBRES. J.G.Morley.

Nature (London), Vol. 184, 1560 (Nov. 14, 1959).

An attempt has been made to eliminate the effect of surface discontinuities on the tensile strength of glass fibres by coating them with a glass which, at elevated temperatures, behaves as a viscous liquid while the core remains a brittle solid. Glass fibres varying in diameter between 0.002 and 0.010 in. were coated with Pyrex glass. The coated fibres were originally about 3 in.long by 0.05 in.thick and were drawn down at their centres to produce test lengths of uniform diameter and about ½ in.long. These were tested in tension at 700° C and compared with uncoated specimens. The cross-sectional area at failure was determined microscopically, the the boundary between the coating and the core being well defined. The tensile strength of the coated fibres was several times greater than that of uncoated specimens of equal diameter.

A.C.Whiffin

539.3

### 4556 THE RELATIONSHIP BETWEEN POLYCRYSTALLINE AND SINGLE CRYSTAL STRAIN CURVES FOR ALUMINIUM. P.Derner and E.Kappler.

Z. Naturforsch., Vol. 14a, No. 12, 1080-1 (Dec., 1959). In German.

Stress-strain curves were obtained at temperatures between −200° and 600°C for Al of various grain sizes. For small extensions, the slope of the curve is independent of temperature but depends on grain size, for larger extensions the slope is highly temperature dependent and independent of grain size. Because of the effect of grain boundaries, no direct relationship can be obtained between polycrystalline and single crystal strain curves. J.Franks

539.3

### 4557 MEASUREMENT OF LOW VALUES OF INTERNAL FRICTION AT ELEVATED TEMPERATURES.

P.D.Southgate.

J. sci. Instrum., Vol. 36, No. 6, 284-7 (June, 1959).

Some features are described of an apparatus which measures internal friction of longitudinally resonant specimens at elevated temperatures. The apparatus uses electrostatic drive and frequency-modulation detection, and operates near 100 kc/s, at temperatures up to 1300° C. Limits of operation are discussed, and a comparison made of the observed amplitude-dependent loss at the specimen supports with a simple theory of frictional loss.

539.3

### 4558 TIME-DEPENDENT INTERNAL FRICTION IN ALUMINUM AND MAGNESIUM SINGLE CRYSTALS.

R.H.Chambers and R.Smoluchowski.

Phys. Rev., Vol. 117, No. 3, 725-31 (Feb. 1, 1960).

Mg and Al single crystals subjected to varying amounts of oscillatory strain of audio frequency were investigated by measuring the strain amplitude-dependent complex dynamical—mechanical modulus at audio frequencies as a function of temperature and time. If the amplitude of the applied excitation exceeds a critical breakaway strain, an excited mechanical state is manifested in a modification of the amplitude dependence of the complex modulus. When the excitation ceases, the excited state decays. The decay following short excitation times obeys a $t^{1/3}$ law, becoming a $t^{2/3}$ law as excitation approaches saturation. The short excitation decay rate is found to be governed by an activation energy in the range of 7-10 kcal per mole. The time dependence is considered to be caused by the dispersal and condensation of a pinning atmosphere which has high diffusivity and is easily dispersed by a dislocation segment undergoing pinning interactions with the atmosphere.

539.3

### 4559 INTERNAL FRICTION OF COLD-WORKED GOLD AND COPPER AT LOW TEMPERATURES.

R.R.Hasiguti and S.Okuda.

Proc. Japan Acad., Vol. 35, No. 6, 284-8 (June, 1959).

The internal friction was measured as a function of temperature between −180 and 80° C. Three peaks appeared in both gold and copper after plastic deformation. Activation energies were calculated from the frequency dependence of the peak temperatures. It appears that the three peaks are associated with the pinning-down of dislocations by single vacancies, single interstitial atoms, and divacancies. B.T.M.Willis

539.3 : 539.2

ASPECTS OF THE THEORY OF INTERNAL FRICTION.
See Abstr. 4289

539.3

### 4560 VARIATIONAL THEOREMS IN GENERAL VISCO-ELASTICITY. W.Olszak and P.Perzyna.

Ingen.-Arch., Vol. 28, 246-50 (1959).

The general linear stress-strain relations involving differentiations and integrations with respect to time are formulated, using a matrix operator notation, for anisotropic bodies, especially of the Voigt, Maxwell and Boltzmann types. Two general variational principles are established for a linear anisotropic body subjected to mixed boundary conditions, one concerned with a variation of displacements (the corresponding stresses not necessarily satisfying the equations of equilibrium) and the other with variations of stress (the corresponding strains not necessarily satisfying the compatibility conditions). J.G.Oldroyd

539

### 4561 TENSILE DEFORMATION OF SINGLE CRYSTAL OF PURE IRON. S.Dohi and T.Yamashita.

J. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 233-46 (Dec., 1958).

An examination of the tensile deformation of single crystals of pure iron by stretching slowly at room temperature and at −72° C i a lengthwise direction, using single crystal plates of definite crysta lographic orientations. The change in the orientation of the tensile axis during elongation was determined by taking X-ray Laue photographs, and the behaviour of slip deformation investigated from the asterism and split of the Laue spots at the various stages of elongation. The slip on both top and side surfaces was examined in detail by optical and electron microscopes. The results obtained were: (1) double slips were operative in the crystals whose plate axes lie within the region about 20° of the [001], or lie near to the [001]-[011 [011]-$[\bar{1}11]$, and $[\bar{1}11]$-[001] lines of the unit stereographic triangle; (2) the slip patterns optically observed on the surface of the deformed specimens do not always indicate the slip bands, because th true slip lines are not always parallel to such patterns, but they ca be detected by combining electron microscopy with X-ray examination; (3) in iron single crystals slip always take place only in the {110} system.

539.

### 4562 THE WORK-SOFTENING EFFECT IN POLYCRYSTALLINE ALUMINIUM. P.Derner and E.Kappler.

Z. Naturforsch., Vol. 14a, No. 12, 1082 (Dec., 1959). In German.

The irreversible change of strain, associated with the work-softening effect, was measured as a function of deformation. The results are interpreted assuming that, within a given distance of a Lomer—Cottrell dislocation, a limited number of screw dislocation are stable, and that this number increases with falling temperature. B.T.M.Willi

539.3 : 534.2

### 4563 THE EFFECT OF ULTRASONIC RADIATION ON THE CREEP OF COPPER SPRINGS. R.Siegel.

Ann. Phys. (Leipzig), Folge 7, Vol. 5, No. 1-2, 107-12 (1959). In German.

The creep of metals is affected by load, temperature and corpuscular radiation. Studies of the effect of ultrasonic vibration on the creep of cylindrical spiral springs of copper showed that the creep is to be ascribed to heating and mechanical working induced by the vibration. B.T.M.Willi

539.3

### 4564 DEFORMATION MECHANISMS DURING CREEP IN METALS. R.Widmer.

Brown Boveri Rev., Vol. 45, No. 11-12, 575-81 (Nov.Dec., 1958)

Systematic creep tests were performed on a coarse-grained austenitic steel at temperatures of 650, 720 and 800° C and at stresses between 0.5 and 8 kg/mm². Microscopic examination and X-ray diffractograms prove that, under definite circumstances, in austenitic steel, as in aluminium and other metals, it is possible to observe a cellular mechanism during creep deformation instead of the normal slip. The nature of the deformation is studied closely in relation to the temperature and stress. Within the range considere mainly crystallographic slip is experienced at high stresses accompanied by severe distortion of the lattice. In contrast, at medium and light stresses it is usually possible to find a cellular mechanism for which, in the process of deformation, the crystals may be subdivided into subgrains whose lattice is undisturbed.

539.3

### 4565 MECHANICAL RELAXATION IN MIXED CRYSTALS OF ICE AND $NH_4F$. E.Walz and S.Magun.

Z. Phys., Vol. 157, No. 2, 266-74 (1959). In German.

The growth of mixed single crystals of ice/$NH_4F$ is described. The mechanical relaxation was measured for the temperature range 0°C to −120°C, in the frequency range 0.5 to 6 kc/s and for concentrations by weight of $NH_4F$ of $1.4 \times 10^{-4}$ and $5.4 \times 10^{-6}$. The simple relaxation process for pure ice is characterized in the mixed crystals by two activation energies, 13.4 and 2.3 kcal/mole. B.T.M.Willis

539.4

### 4566 VACUUM FATIGUE-APPARATUS. N.J.Wadsworth.

J. sci. Instrum., Vol. 36, No. 6, 274-7 (June, 1959).

An apparatus is described in which it is possible to anneal specimens in vacuo and then fatigue them in vacuo or in any desired mosphere without intermediate exposure to air. Annealing temperatures of up to 800°C are used and extension up to 1000°C is possible. The specimens are flat sheets. An electromagnetic drive is used to fatigue them in reversed bending between constant strain limits at 100 c/s. Both extremes of the movement of the specimens are monitored optically and a servo system keeps them constant in spite of changes in the modulus or damping of the specimens during the test. An automatic cut-out stops the test as soon as a large crack appears in the specimen. Some typical results are shown.

539.4

### 4567 DIRECT STRESS MACHINE FOR COMBINED FATIGUE AND CREEP TESTING.

A.H.Meleka.

sci. Instrum., Vol. 36, No. 11, 468-7 (Nov., 1959).

The report describes the modifications introduced to a commercial creep testing machine so that tests under combined fatigue and creep conditions can be carried out. Results are given illustrating the performance of the converted machine. Limitations and further modifications are briefly discussed. The combined testing machine is now commercially available.

539.4

### 4568 RELATIONSHIP BETWEEN STRENGTH AND POROSITY FOR COAL COMPACTS.

D.J.Millard.

Brit. J. appl. Phys., Vol. 10, No. 6, 287-90 (June, 1959).

When powdered coal is compacted by subjecting it to high pressures it is found that the quality of the compact as measured by strength tests is, for a given batch of powder, a single valued function of the porosity of the compact. The shape of this strength—porosity curve cannot be explained by treating the pores as if they only reduced the load bearing area available to withstand stresses in the compact. The form of the observed strength—porosity curves for compacts tested at right angles to the direction of compaction has been explained in terms of the development of contacts between particles with increasing compaction, and of the changing action of pores as stress magnifiers. A strength—porosity relationship of the form $\sigma = (1 - \bar{p})\bar{p}^{-1}$ has been deduced, where $\bar{p}$ ("rationalized" porosity) is the ratio of the porosity of the compact to that of the pile of loose powder having no mechanical strength. It has been shown that this expression gives a good representation of the experimental data.

539.4

### 4569 INFLUENCE OF THE PARAMETERS OF CYCLIC HEAT-TREATMENT ON THE MECHANICAL AND PHYSICAL PROPERTIES OF ZINC.

V.D.Kuznetsov, A.I.Surnacheva and L.P.Rozhkova.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 5, 927-9 (Oct. 11, 1959). In Russian.

In a study of the breakdown of zinc by the formation of cracks caused by thermal cycling, specimens of 99.95% pure zinc 100 mm long and 1.5 mm diameter were subjected to a number of cycles (n) of the following regimes, specified by maximum temperature (T) and time of exposure to the maximum temperature ($\tau$): (1) T = 130° C, $\tau$ = 1 min; (2) T = 250° C, $\tau$ = 1 min; (3) T = 250° C, $\tau$ = 3 min; (4) T = 300° C, $\tau$ = 3 min. In each cycle, the specimens were cooled for 1 min in water at 10° C. The electrical resistance was measured as a function of n in all 4 regimes; tensile strength and relative extension were measured as functions of n in regimes (1) and (2) only. The properties were unaffected by regime (1). Electrical resistance in regimes (2), (3) and (4) increased with increasing n, and for a given n was always in the order $(1) < (2) < (3) < (4)$. Regime (2) lowered the breaking strength and relative extension in relation to regime (1) by an amount which increased with n.

R.F.S.Hearmon

539.4

### 4570 QUENCH HARDENING IN ALUMINIUM SINGLE CRYSTAL PLATES. I.

T.Kino.

J. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 259-66 (Dec., 1958).

Quench hardening in aluminium single crystal plates was investigated by taking their stress-strain curves and their X-ray diffraction patterns. The recovery process was also studied. The results obtained in these experiments may be summarized as follows: (1) There is no orientation dependence in quench hardening of aluminium single crystals. (2) Increment of critical stress due to quenching increases linearly with quenching temperature below 300° C, and exponentially above. (3) The recovery process of quench hardening in aluminium single crystals is composed of more than two processes. (4) Localized plastic strain produced during quenching scarcely contribute to the hardening. It seems that the causes of hardening are quenched-in lattice defects, especially vacancies and the internal stress introduced by quenching.

539.6

### 4571 FRICTIONAL FORCES AND SURFACE DEFORMATION.

V.D.Evdokimov, V.S.Radchik and A.S.Radchik.

Dokl. Akad. Nauk SSSR, Vol. 128, No. 5, 921-3 (Oct. 11, 1959). In Russian.

A linear relationship is found between surface deformation and frictional force for steel, bronze, cast iron, aluminium and textolite, with and without lubrication, using a special apparatus, which is described. The influence of various lubricants on the curve for a steel-steel interface is also investigated.

R.F.S.Hearmon

539.6

### 4572 ROLLING FRICTION OF POLYMERIC MATERIALS. I. ELASTOMERS.

D.G.Flom.

J. appl. Phys., Vol. 31, No. 2, 306-14 (Feb., 1960).

Coefficients of friction for the rolling of steel balls on butyl, silicone and Neoprene elastomers have been measured in the temperature range of 25° to 100° C. For equivalent amounts of deformation, rolling friction is directly proportional to dynamic mechanical losses measured by a rebound method. In addition, the coefficients of friction vary directly with $(\text{load})^{1/3}$ and inversely with $(\text{ball radius})^{2/3}$. These results are in agreement with recent theoretical predictions. The high mechanical losses and rolling friction for the butyl elastomer at 25° C drop sharply on increasing the temperature to 100° C. For the silicone and the Neoprene the losses and the friction decrease only slightly with increase in temperature.

539.6

### 4573 AN APPARATUS FOR INVESTIGATING EXTERNAL STATIC FRICTION IN A CONTROLLED ATMOSPHERE AND IN VACUUM.

Yu.P.Toporov and V.P.Lazarev.

Pribory i Tekh.Eksper., 1959, No.3, 123-4 (May - June). In Russian.

An apparatus is described for measuring the surface friction of solid bodies in vacuo ($10^{-2}$ to $10^{-3}$ mm Hg) and in controlled atmospheres of water vapour and organic compounds. The relative displacement of the surfaces in contact is controlled magnetically. All rubbing parts of the apparatus are of Teflon and work without grease, thus removing the possibility of surface contamination.

R.F.S.Hearmon.

539.6 : 539.2 : 537.311

### 4574 ON THE POSSIBLE ROLE PLAYED IN ADHESION PHENOMENA BY THE DOUBLE ELECTRICAL LAYER FORMED AT THE SOLID—SOLID INTERFACE.

V.B.Sandomirskii and V.P.Smilga.

Fiz. tverdoga Tela, Vol. 1, No. 2, 307-14 (Feb., 1959). In Russian.

Theoretical. Formulae for the force of adhesion were derived for the cases of an n-type semiconductive layer (a) in contact with metal, and (b) between two metals. The analysis was based on the standard method of the so-called "physical barrier-layer" (uniform distribution of the donor atoms across the thickness of the semiconductor), and it was assumed that the work function of the semiconductor was greater than that of the metal. It was inferred from the results that, in addition to molecular forces, electrostatic forces associated with the formation of the double electrical layer may also play an important part in adhesion between solids.

M.H.Sloboda

539.62 : 531.4

THEORY OF ROLLING FRICTION. See Abstr. 3477-8

## CRYSTALLOGRAPHY

## CRYSTAL STRUCTURES

539.2 : 548

### 4575 THE SYMMETRY OF MULTICOLOURED POLYHEDRA.

O.Wittke and J.Garrido.

Bull. Soc. Franc. Mineral. Crist., Vol. 82, No. 7-9, 223-30 (July-Sept., 1959). In French.

The possible symmetries of the crystallographic polyhedra when the colouring of the faces is considered are tabulated. The numbers of groups of s colours in each crystal system are tabulated for each value of s. s may be 2, 3, 4, 6, 8, 12, 16, 24, or 48 and in all there are 211 groups. The coloured sub-groups of each of the 32 point groups are tabulated.

A.L.Mackay

539.2 : 548

4576 PRESENTATION AND STUDY OF A QUARTZ CRYSTAL WITH CAVITIES OF DEFINITE CRYSTALLOGRAPHIC FORM. M.Sayar.

Bull. Soc. Franc. Mineral. Crist., Vol. 82, No. 7-9,231-3 (July-Sept., 1959). In French.

A morphological description is given of a single quartz crystal containing cavities of crystallographic form. These "negative crystals" have vicinal faces, like the quartz crystal itself.

B.T.M.Willis

539.2 : 548

4577 RELATIONS BETWEEN THE ENTROPY OF FUSION AND THE CRYSTALLINE STRUCTURE. C.Bourlange.

Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 9-10, 1017-45 (Sept.-Oct., 1959). In French.

A detailed description of a systematic cryometric study of the alkali salts of acids containing complex oxygen anions of the general type $A_2BX_4$, derived from Gp. VI elements: sulphates, chromates, molybdates and tungstates. The apparatus is described and shown diagrammatically. The effect of the different anions for a salt of given cation A, and for the same anion the effect of the nature of the cations, was determined. S.Weintroub

539.2 : 548

4578 A CONTRIBUTION TO STUDIES ON THE HYDRATED OXIDES OF URANIUM. J.Protas.

Bull. Soc. Franc. Mineral. Crist., Vol. 82, No. 7-9, 239-72 (July - Sept., 1959). In French.

Hydrated uranium oxides can be precipitated by reaction in aqueous solution between uranyl salts and calcium, strontium, barium, lead and bismuth salts at temperatures between 100° and 180° C. Among other minerals which have been synthesized are schoepite $U_4O_9(OH)_6.5H_2O$, becquerelite $CaU_6O_{16}(OH)_6.8H_2O$, billietite $BaU_6O_{16}(OH)_6.8H_2O$, curite $3PbO.8UO_35H_2O$, fourmarierite $PbO.4UO_3.5H_2O$, vandendriesscheite $PbO.7UO_3.12H_2O$ and uranospherite $UO_4Bi(OH)$. The physical and chemical properties (density, optical properties, crystallographic properties) and the main locations have been newly measured or confirmed for each material. The study of typical specimens from different strata led to the description of two new minerals: a complex hydrated oxide of U, Ca and Sr from the French deposit of Margnac II and a double hydrated oxide of U and Pb, wolsendorfite $(Pb,Ca)U_2O_7.2H_2O$ from Wolsendorf (Bavaria) hitherto confused with fourmarierite. As a result of the work in synthesizing these minerals conclusions on their natural genesis and inter-relationships can be drawn. A.L.Mackay

539.2 : 548

4579 THE SPONTANEOUS FRAGMENTATION OF THORIANITE ON HEATING. R.S.Barnes and D.J.Mazey.

J. nuclear Energy, Vol. 5, No. 1, 1-3 (1957).

Natural thorianite, containing large amounts of helium from the radioactive decay processes occurring in it, fragments explosively at 950° C when slowly heated. This behaviour is attributed to the helium precipitating as high-pressure gas at flaws in the mineral.

539.2 : 548

4580 EFFECT OF ALPHA-BETA THERMAL CYCLING ON URANIUM AND ITS ALLOYS. B.R.Harward.

Nucleonics, Vol. 17, No. 8, 74-7 (Aug., 1959).

Powder-compacted or $\alpha$-rolled uranium specimens were subjected to either slow or fast thermal cycling through the $\alpha-\beta$ transition temperature (660°C) and the changes in dimensions and structure determined. Dilute alloys of Nb, Cr, Bi, Sn, Al, Si, Mo, and Zr and the restraining effect of thin stainless steel jackets were also investigated. Most materials show large dimensional instabilities.

R.D.Smith

539.2 : 548

4581 CRYSTALLINE STRUCTURE AND ISOMORPHISM OF SOME Co$^{III}$ CYANIDES WITH BIVALENT CATIONS.

A.Vaciago and A.Mugnoli.

R.C. Accad. Naz. Lincei, Vol. 26, No. 4, 517-22 (April, 1959). In Italian.

Discusses the compounds $_3[Co(CN)_6]_2$ where X = Mn, Fe, Co, Ni, Cu and Zn. Values of $d_{hkl}$ are given. J.M.Hough

539 2 : 548

4582 THE INVERSION OF CRISTOBALITE. O.Krisement and G.Trömel.

Z. Naturforsch., Vol. 14a, No. 10, 912-19 (Oct., 1959). In German.

The $\alpha \rightleftharpoons \beta$ inversion of a large number of micro-crystals was observed under the microscope. The curve relating the number of crystals to the inversion temperature was that expected from calorimetric data. The inversion behaviour of a large sample is determined by two factors : the Gaussian distribution of inversion temperature of the micro-crystals in the sample, and the Gaussian distribution of the hysteresis of the inversion temperature for heati and cooling. B.T.M.Will

539.2 : 548 : 537.

4583 SYMMETRY OF THE LOW-TEMPERATURE PHASE OF BARIUM TITANATE. E.Sawaguchi and M.L.Charters.

Phys. Rev., Vol. 117, No. 2, 465-9 (Jan. 15, 1960).

In order to find the crystal symmetry of $BaTiO_3$ below −80° C, the domain patterns and optical properties were examined using thi (1̄11) plates specially prepared for this purpose. Four kinds of domains were differentiated; these domains are optically uniaxial. The crystal symmetry proved to be rhombohedral. The effect of a d.c. field on the domain configuration was studied. Explanations were given for the strange dielectric and optical behaviour which had been thought paradoxical.

539.2 : 548.

4584 EVIDENCE OF TWO KINDS OF TWINS IN COPPER LAYERS BY THERMAL EVAPORATION ON A (111) FACE OF A COPPER SINGLE CRYSTAL. Nguyen Quat Ti.

C.R. Acad. Sci. (Paris), Vol. 249, No. 22, 2301-3 (Nov. 30, 1959). In French.

This is a short note describing the diffraction pattern from a copper layer on a copper single crystal. When ion bombardment cleaning of the crystal surface is used two types of twin may be formed in the layer. A.E.I. Research Laborator

539.2 : 548.

4585 DEFORMATION TWINS IN WHITE TIN.

I. THE APPEARANCES AND KINDS OF DEFORMATIO TWINS. T.Hirokawa.

J. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 225-32 (Dec., 1958).

With many single crystal plates and rods of white tin having one of the crystallographic orientations distributed uniformly in a stereographic triangle, prepared by applying Fujiwara's method, deformation twins of various shapes and kinds can be produced by compressing the specimen in a lengthwise direction by impact. The twins of various shapes thus produced are mostly the so-called "(301) twins", but the shapes and kinds differ according to the orientation of the specimen, i.e. the direction of compression. The critic energy for producing these (301) twins by impact is estimated as $3.5 \times 10^5$ erg/cm$^2$, and the orientation dependence is discussed. Wh the direction of compression is a particular one, so-called "(101) twins" are produced, branching out of large (301) twins. On the basi of the results obtained, (301) twins of any desired shape and kind car be produced.

539.2 : 548.

4586 INVESTIGATION OF CONCENTRATION DISTRIBUTION AROUND CRYSTALS IN AQUEOUS SOLUTIONS.

G.Domokos and L.Malicskó.

Acta phys. Hungar., Vol. 10, No. 2, 185-93 (1959).

Concentration distribution around growing and dissolving crystals was measured by a phase contrast method. The measurements indicate the existence of a boundary layer around the crystals as discussed previously by Gyulai (Abstr. 9149 of 1952).

539.2 : 548.5

4587 CELLULAR GROWTH IN TIN ALLOYS. T.S.Plaskett and W.C.Winegard.

Canad. J. Phys, Vol. 37, No. 12, 1555-7 (Dec., 1959).

Tiller's equation, giving the conditions under which cellular growth takes place, was confirmed experimentally in work on zone-refined tin with additions of lead, bismuth or antimony. The results justify the use of the equation for any metal system, regardless of its crystal structure. B.T.M.Willis

539.2 : 548.5

4588 PARTICLE-INTEGRATION RATE IN CRYSTAL GROWTH R.Cartier, D.Pindzola and P.F.Bruins.

Industr. engng. Chem., Vol. 51, No. 11, 1409-14 (Nov., 1959).

An equation of Amelinckx [J. Chim. phys., Vol. 47, 213 (1950)] is modified to correlate measurements of growth rates of citric and itaconic acid crystals in aqueous solutions. The apparatus is described and measurements of the temperature dependence of some of the parameters is also given. J.E.Caffyn

539.2 : 548.5

**4589** GROWTH AND CRYSTAL SYMMETRY OF METAL CHELATE SALT CRYSTALS.
L.G.Van Uitert and R.G.Treuting.
J. chem. Phys., Vol. 32, No. 2, 322-4 (Feb., 1960).

A method for growing large single crystals of metal chelate salts such as NaNi triacetylacetonate·p-dioxane and NaNi triacetylacetonate·benzene has been devised. The growth habits of these crystals are described. X-ray studies of three of the NaNi and NaMg salts indicate a diffraction symmetry consistent with space group $P\bar{3}1c$, with two molecules per unit cell. Paramagnetic resonance measurements by Peter indicate that the benzene compounds are truly trigonal, while the dioxane compounds are macroscopically trigonal as a result of disordering among unit cells that are individually monoclinic.

539.2 : 548.5

**4590** ON THE GROWTH CONDITIONS OF GERMANIUM. T.Sasaki.
J. Phys. Soc. Japan, Vol. 14, No. 3, 381-2 (March, 1959).

Ge crystals were pulled from the melt at different growth rates and temperature gradients. Etch pit density depended on growth conditions, and a relationship was found between noise under illumination and dislocation density. The noise remained constant at low light intensities and decreased suddenly when the intensity exceeded a critical value depending on growth conditions. J.Franks

539.2 : 548.5

**4591** SPIRAL AND OTHER GROWTH FORMS OF SYNTHETIC DIAMONDS: A DISTINCTION BETWEEN NATURAL AND SYNTHETIC DIAMOND. S.Tolansky and I.Sunagawa.
Nature (London), Vol. 184, 1526-7 (Nov. 14, 1959).

Studies are reported on G.E. synthetic diamonds using a sensitive phase-contrast microscope. New features appear which have never been recorded in natural diamonds. These include (1) appearance of dentritic forms, (2) cubic faces exhibiting a high degree of optical plane perfection (natural cube faces are very rough), (3) spiral growths often appear on the cube faces, usually originating at corners, (4) slip lines often appear on the surfaces. All these are clear distinctions between natural and synthetic diamonds.
S.Tolansky

539.2 : 548.5

**4592** IMPROVED APPARATUS FOR FLOATING-ZONE MELTING BY ELECTRON BOMBARDMENT.
F.E.Birbeck and A.Calverley.
J. sci. Instrum., Vol. 36, No. 11, 460-3 (Nov., 1959).

Provision is made for zoning speeds of 0-350 cm/hr with bombarding voltages up to 10 kV at 500 mA. The operating vacua are of the order 10$^{-6}$ mb or better. Up to 22 cm of specimen length can be zoned.

539.2 : 548.5 : 621.365.9

**4593** THE GROWING OF 5 kg SINGLE CRYSTALS OF GERMANIUM.
J.G.Wilkes.
Proc.Instn Elect. Engrs,Paper 2934 E, publ. May, 1959 [International Convention on Transistors and Associated Semiconductor Devices] Vol. 106B, Suppl. 17, 866-70, 883-4 (1959).

Republication, with discussion of the paper abstracted in Abstr. 7595 (1959).

539.2 : 548.5 : 537.311

**4594** THE CONTROL OF RESISTIVITY IN PULLED SILICON CRYSTALS. A.Trainor and P.T.Harris.
Proc. Phys. Soc., Vol. 74, Pt 5, 669-70 (Nov., 1959).

The control is achieved by pulling in a reduced pressure of ambient gas such that the segregation of impurity from the solid to the liquid is balanced by the evaporation of impurity from the surface of the melt. The theory is given, and experiments to verify it are described. C.Hilsum

539.2 : 548.5

**4595** ON THE FORMATION OF HEXAGONAL GOLD AND COPPER BY CONDENSATION FROM THE VAPOUR ON THE CLEAVAGE FACE (0001) OF A ZINC SINGLE CRYSTAL.
J.J.Couderc, J.Garigue, L.Lafourcade and Quat Ti Nguyen.
C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2037-9 (Nov. 16, 1959).
In French.

A quantity of gold or copper was evaporated on to the cleaved surface of a zinc single crystal. The deposit was then bombarded by positive ions. At some stage in this process a hexagonal structure is revealed by electron diffraction. The structure has not yet been obtained without the aid of ion bombardment.
A.E.I. Research Laboratory

539.2 : 548.5 : 535.33

MgSO$_4$.7H$_2$O CRYSTAL GROWTH BY THERMO-SYPHON METHOD. See Abstr. 4422

539.2 : 548.5

**4596** ON THE GROWTH OF NaCl FROM THE SUBLIMED VAPOR. Chang Yuan-Lung.
Z. phys. Chem. (Leipzig), Vol. 212, No. 3-4,167-74 (1959).

A general description of the appearance of deposits of NaCl obtained on surfaces at various temperatures up to 780°C, including the frequencies of occurrence of various crystal faces.
A.R.Stokes

539.2 : 548.5

**4597** MECHANISM FOR THE GROWTH OF WHISKERS FROM SOLUTION ON AN IMPERVIOUS SUBSTRATE.
S.Amelinckx.
J. chem. Phys., Vol. 31, No. 6, 1687-8 (Dec., 1959).

See Abstr. 5518 (1958). A formula for the maximum rate of whisker growth due to flow of solution up a central channel gives a result agreeing with experiment. A.R.Stokes

539.2 : 548.5 : 537.311

**4598** THE PREPARATION AND PROPERTIES OF ALUMINUM ANTIMONIDE.
W.P.Allred, W.L.Mefferd and R.K.Willardson.
J.Electrochem. Soc., Vol. 107, No. 2, 117-22 (Feb., 1960).

An improved method of growing single crystals of aluminium antimonide is described. Oxide from the aluminium has been eliminated by a vacuum heat-treating technique which also removes volatile impurities. The mobility of the positive carriers in AlSb at 300°K is found to be greater than 400 cm$^2$/(V sec). Values as high as 5000 cm$^2$/(V sec) have been measured at 50°K. The p-type impurities have an activation energy of about 0.02 eV in AlSb. A maximum is observed at 4000 G in the magnetic-field dependence of the Hall coefficient at 77°K.

539.2 : 548.5

**4599** RECRYSTALLIZATION OF THE STRETCHED ALUMINIUM SINGLE CRYSTAL PLATES.
T.Kino and T.Fujiwara.
J. Sci. Hiroshima Univ, A, Vol. 22, No. 3, 251-7 (Dec., 1958).

Recrystallization of stretched aluminium single crystal plates having various kinds of crystallographic orientations was studied. The results obtained may be summarized as follows: (1) The critical stress necessary for recrystallization is different according to the initial crystallographic orientations of the single crystals. (2) In some specimens, it is found that the orientation relationship between the deformed matrix and the recrystallized grains is a 30° to 40° rotation around the $\langle 211 \rangle$ axis on the slip plane and perpendicular to the slip direction of the main slip system.

539.2 : 548.5

**4600** CHEMICAL ETCHING OF SILICON. II. THE SYSTEM HF, HNO$_3$, H$_2$O, AND HC$_2$H$_3$O$_2$. H.Robbins and B.Schwartz.
J. Electrochem. Soc., Vol. 107, No. 2, 108-11 (Feb., 1960).

For Pt I, see Abstr. 9008 (1959). The kinetics of the reaction of silicon with solutions of hydrofluoric acid, nitric acid, and acetic acid are reported as a function of the composition of the etchant. The system qualitatively behaves in the same manner as the system hydrofluoric acid, nitric acid, and water, which has been reported previously. Quantitatively, the acetic acid diluted system shows a much higher tolerance for the diluent than does the water diluted system. The greater tolerance for acetic acid has been explained on the basis of the lesser ionization of nitric acid in acetic acid than in water. The reaction mechanisms postulated for the water diluted system have been found to apply equally well to the acetic acid diluted system.

539.2 : 548.5

**4601** ETCH PATTERNS ON FERROELECTRIC TRIGLYCINE SULPHATE. H.Toyoda.
J. Phys. Soc. Japan, Vol. 14, No. 3, 376 (March, 1959).

Water and various organic liquids were used to etch cleavage surfaces and demonstrated a correlation between the etch pits and the polarization of ferroelectric domains. C.A.Hogarth

539.2 : 548.5

### 4602 ETCHING OF CALCITE.

N.S.Pandya and J.R.Pandya.

Nature (London), Vol. 184, 894-5 (Sept. 19, 1959).

Observations are reported on the etching of calcite with (a) sodium hydroxide (b) ammonium chloride. The etching figures are studied with the light-profile microscope and with multiple-beam interferometry. S.Tolansky

539.2 : 548.7

### 4603 THE TEMPERATURE DEPENDENCE OF THE STRUCTURE OF ATOMS IN SOLIDS.

R.Hosemann and G.Voigtlaender-Tetzner.

Z. Electrochem., Vol. 63, No. 8, 902-8 (1959). In German.

A general review with special reference to the X-ray data concerning the fluctuation in electron densities. P.T.Landsberg

539.2 : 548.7 : 535.8

PRINCIPLES AND APPLICATIONS OF DIFFRACTION MICROSCOPY OVER THE WAVELENGTH RANGE FROM VISIBLE LIGHT TO GAMMA RAYS. See Abstr. 3614

539.2 : 548.7

### 4604 DEVELOPMENTS AND FUTURE AIMS OF NEUTRON DIFFRACTION. G.L.Bacchella.

Energia nucleare, Vol. 7, No. 1, 11-22 (Jan., 1960). In Italian.

A short outline of the physical principles of neutron diffraction is given, and similarities between neutron diffraction and X-ray diffraction are summarized. Experimental techniques are described and future developments considered.

539.2 : 548.7

### 4605 UNIVERSAL GNOMONIC PROTRACTORS FOR TRANSMISSION AND BACK-REFLECTION LAUE PHOTOGRAPHS. Chang Yuan-Lung.

Exper. Tech. der Phys., Vol. 7, No. 4, 162-7 (1959).

Describes a device that employs the principle used by Clark and Gross (Abstr. 4827 of 1937). A.R.Stokes

539.2 : 548.7

### 4606 IMPROVED MICROBEAM BACK-REFLEXION X-RAY CAMERA WITH ARRANGEMENT FOR IRRADIATING A PRE-SELECTED AREA. H.M.Otte and R.W.Cahn.

J. sci. Instrum., Vol. 36, No. 11, 463-5 (Nov., 1959).

For use in conjunction with a microfocus X-ray tube. It has the advantage over previous cameras of being more rapid and precise in setting and of enabling much shorter exposure times to be used for X-ray beams of 10 to 50 $\mu$ in diameter.

539.2 : 548.7

### 4607 X-RAY ANALYSIS TECHNIQUE FOR VERY HIGH TEMPERATURES. E.Aruja, J.H.Welch and W.Gutt.

J. sci. Instrum., Vol. 36, No. 1, 16-20 (Jan., 1959).

A new powder-diffraction technique for very high temperatures is described, in which a thermocouple combines the functions of sample support, heating, and temperature measurement. This device is simple, compact and inexpensive, and has proved to be very reliable. The maximum working temperature depends on the thermocouple material, and is normally 1750°C using 5/20 rhodium—platinum, or 1850°C with 20/40 rhodium—platinum couples.

539.2 : 548.7

### 4608 HIGH-TEMPERATURE X-RAY DIFFRACTOMETER.

J.Spreadborough and J.W.Christian.

J. sci. Instrum., Vol. 36, No. 3, 116-18 (March, 1959).

A vacuum furnace designed for use with a commercial diffractometer is described. It uses a high-current heater made from tantalum foil, and allows the full Bragg spectrum to be recorded whilst satisfying the Bragg—Brentano focusing condition. The specimen temperature is uniform and can be measured accurately; the furnace has been operated successfully at temperatures up to 1100°C, and it is believed that considerably higher temperatures can be achieved.

539.2 : 548.7

### 4609 MONITORED GEIGER COUNTER X-RAY DIFFRACTOMETER WITH AUTOMATIC RECORDING.

E.R.Pike and J.W.Hughes.

J. sci. Instrum., Vol. 36, No. 5, 212-23 (May, 1959).

The equipment produces automatically a compact photographic record of a step-scan of a powder diffraction pattern in steps of 0.02° ($2\theta$). It is arranged that movement over the background region between lines is rapid, so that only the line profile and the immediate background on either side are recorded in detail. The specialized electronic circuits and the relay-operated automatic sequence control circuits are described, together with a special automatic camera provided with various safety devices to protect the record. Facilities for other scanning procedures are also provided.

539.2 : 548.7

### 4610 APPLICATION OF THE COUNTER-TUBE GONIOMETER TO X-RAY FINE-STRUCTURE DETERMINATION.

A.Esenwein and H.Preis.

Schweiz. Arch. angew. Wiss. Tech., Vol. 25, No. 7, 225-30 (July, 1959). In German.

A procedure is described, in some detail, for finding the proportions of rutile and anatase in titanium dioxide white pigment. Possible errors due to differential absorption and due to line broadening are considered. A.R.Stokes

539.2 : 548.7

### 4611 LOW-TEMPERATURE CAMERA FOR STRUCTURE INVESTIGATIONS WITH A COUNTER GONIOMETER.

H.Peisl and W.Waidelich.

Z. angew. Phys., Vol. 11, No. 12, 474-7 (Dec., 1959). In German.

A vacuum-jacketed camera for operation at liquid hydrogen temperature is described. X-rays enter and leave the vacuum chamber through thin foil supported on a perforated metal base. A.R.Stokes

539.2 : 548.7 : 539.1.07

### 4612 USE OF SCINTILLATION COUNTERS IN SINGLE CRYSTAL X-RAY DIFFRACTOMETRY.

P.J.Black and J.B.Forsyth.

J. sci. Instrum., Vol. 36, No. 9, 392-4 (Sept., 1959).

The paper describes a scintillation counter apparatus used for single-crystal X-ray diffractometry. The variation of the signal/noise ratio with photomultiplier operating potential has been investigated for the Du Mont 6291 tube, and it is shown that the resolution of the signal pulses from the noise background improves as this potential is decreased. Signal resolutions of 26, 29 and 43% have been obtained with AgK$\alpha$, MoK$\alpha$ and CuK$\alpha$ radiations, respectively, the mean number of photoelectrons released per keV incident quantum energy being 6. Stability criteria which will help to ensure the overall uniformity in the counter response are suggested.

539.2 : 548.7

### 4613 APPARATUS FOR DIRECT OBSERVATION OF LOW-ENERGY ELECTRON DIFFRACTION PATTERNS.

E.J.Scheibner, L.H.Germer and C.D.Hartman.

Rev. sci. Instrum., Vol. 31, No. 2, 112-14 (Feb., 1960).

An apparatus for the observation of low-energy electron diffraction patterns on a fluorescent screen is described. The diffracted electrons pass through a pair of grids and then are accelerated by a potential difference of the order of $10^3$ V to excite the fluorescent screen. The equipment is designed for high vacuum and pressures below $2 \times 10^{-10}$ mm Hg have been maintained. Different gases can be introduced at low controlled pressures ($10^{-9}$ to $10^{-7}$ mm Hg) and diffraction patterns produced by adsorbed layers can be photographed and studied. Typical diffraction patterns from a clean (111) face of a nickel crystal and from oxygen adsorbed upon this face are reproduced here.

539.2 : 548.7 : 536.48

### 4614 LIQUID-HELIUM GONIOMETER-MOUNTED CRYOSTAT FOR A SINGLE CRYSTAL AUTOMATIC NEUTRON DIFFRACTOMETER. S.C.Abrahams.

Rev. sci. Instrum., Vol. 31, No. 2, 174-6 (Feb., 1960).

An all-metal cryostat capable of maintaining a single crystal at liquid helium temperatures is described. One filling of liquid helium lasts over 10 days. Crystal orientation is obtained by mounting the cryostat on a large goniometer head and tilting the entire cryostat to the required position. The maximum semi-vertical angle is 20°. The complete assembly is used with this diffractometer for routine measurement of the diffracted neutron intensities from single crystals in the temperature range between about 4.6° and 1.5°K.

539.2 : 548.7

### 4615 STUDY OF PERFECTION OF CRYSTALS USING POLARIZED X-RAYS. K.S.Chandrasekaran.

Acta cryst., Vol. 12, Pt 11, 916-22 (Nov., 1959).

A new method of assessing the perfection of crystals by using polarized X-rays was tested in detail and the measurements for a umber of crystals are reported. The polarization ratio (ratio of e integrated intensities for the two orthogonal states of polarizaon) was found to lie in all cases within the limits set by theory. he absolute intensity and the width of reflections were also measred and a comparison was made of the different methods of studyg the perfection of crystals. It was found that the measurements ere simpler by the new method. The limitations and the optimum onditions for measurements are discussed.

539.2 : 548.7

### 4616 POWDER TECHNIQUE FOR THE EMPIRICAL DETERMINATION OF ABSORPTION CORRECTIONS.

I.A.R.Wegener.

Brit. J. appl. Phys., Vol. 10, No. 9, 406-9 (Sept., 1959).

The X-ray absorption factors necessary in the accurate determination of intensities in X-ray diffraction structure analyses can e obtained empirically by an analogue technique. This is accomlished by replacing the single crystal in its camera by a powder specimen of the same shape, macroscopic orientation and absorption roperties, and recording the pattern as the camera goes through he same motions as performed before with the single crystal. The atterns arising in conjunction with different cameras are described, he correction factors necessary are pointed out, and the technique of finding relative and absolute absorption factors with the help of a pattern having calculable absorption factors is elucidated. The correction factors peculiar to this technique are derived analytically.

539.2 : 548.7

### 4617 SOME EXPERIMENTAL RESULTS OF INVESTIGATION OF ORGANIC MOLECULES WITH DIFFUSE X-RAY SCATTERING IN CRYSTALS. W.Hoppe.

Z. Elektrochem., Vol. 63, No. 8, 912-20 (1959). In German.

The theory of diffuse scattering of X-rays by crystals containing stiff groups of atoms is applied to the problem of the structure analysis of these stiff groups from the X-ray data. The analysis of phyllochlorine ester and of tetrachloroketo-naphthalene are given as examples. A.R.Stokes

539.2 : 548.7

### 4618 SMALL ANGLE INTENSITIES FROM DOUBLE REFLECTIONS IN POWDER SAMPLES. B.E.Warren.

Acta cryst., Vol. 12, Pt 11, 837-41 (Nov., 1959).

A small-angle intensity is to be expected from double reflections in any powder sample comprising small grains with random orientation. The inter-grain contribution is due to an hkl reflection in one grain, followed by the same hkl reflection in another grain. The intra-grain contribution arises from a hkl reflection followed by a $\bar{h}\bar{k}\bar{l}$ reflection in the same grain. The inter-grain intensity is independent of grain size and falls off inversely as the scattering angle. The intra-grain intensity depends upon grain size, and falls off rapidly with scattering angle. Equations are obtained for both types of contribution. Cold work in a sample breaks up the original grains into small sub-grains with a small variation in orientation. The enhanced inter-grain contribution from these groups of suggrains can produce a strong small-angle scattering.

539.2 : 548.7

### 4619 PRECISION LATTICE PARAMETER MEASUREMENTS OF COLD-WORKED METALS. R.Asimow.

J. appl. Phys., Vol. 31, No. 2, 410-11 (Feb., 1960).

A technique is developed for precise measurement of interplanar spacings under conditions such that both crystal imperfections and the finite X-ray spectrum contribute significantly to the broadening of the diffraction peaks. This is accomplished by considering the variation of the interference function in the neighbourhood of a reciprocal lattice point. A weighted average value of $\sin\theta$, which corresponds to the interference function centroid, is calculated from the usual intensity versus angle data for a diffraction peak. Comparison of this measurement, with that obtained by using the position of maximum intensity, indicates that errors greater than 0.1% may be expected with the latter technique depending on the shape of the diffraction peak.

539.2 : 548.7 : 539.18

### 4620 X-RAY INCOHERENT SCATTERING FUNCTIONS FOR NON-SPHERICAL CHARGE DISTRIBUTIONS: N, $N^-$, $O^-$, O, $O^+$, $O^{+2}$, $O^{+3}$, F, $F^-$, $Si^{+4}$, $Si^{+3}$, Si, AND Ge. A.J.Freeman.

Acts cryst., Vol. 12, Pt 11, 929-36 (Nov., 1959).

The atomic incoherent scattering functions were calculated according to the Waller–Hartree theory as extended in a previous paper (Abstr. 4675 of 1959) to include the effects of the inherent non-sphericity of the atomic charge distributions. Hartree–Fock wave-functions were used in all the computations. The results obtained show large deviations from the previously reported values of James and Brindley. These differences arise mainly from the inclusion in the present calculations of all the exchange integrals in the Waller–Hartree expression.

539.2 : 548.7

### 4621 RATIONAL DEPENDENCE AND THE RENORMALIZATION OF STRUCTURE FACTORS FOR PHASE DETERMINATION. H.Hauptman and J.Karle.

Acta cryst., Vol. 12, Pt 11, 846-50 (Nov., 1959).

The effect of rationally dependent atoms on phase determining formulae is described. This leads to a procedure for reinterpreting and modifying these formulae which is based upon the examination of subsets of the experimental data and a subsequent renormalization of structure factors. Although the nature of the renormalization is structure dependent, no previous structural knowledge is required for carrying out the procedure or computing phases. An example illustrating the features of rational dependence and renormalization is included.

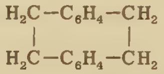
539.2 : 548.7

### 4622 AN X-RAY STUDY OF RIGID-BODY AND INTERNAL VIBRATIONS OF ORGANIC MOLECULES.

K.Lonsdale and H.J.Milledge.

Nature (London), Vol. 184, 1545-9 (Nov. 14, 1959).

Evidence is collected which shows that intra-molecular vibrations cannot be neglected if agreement between observed and calculated X-ray diffracted intensities is to be obtained. A detailed study has been made of the vibrations of various molecules, such as



$$\begin{array}{l} H_2C-C_6H_4-CH_2 \\ \ \ \,| \qquad\qquad\ \ | \\ H_2C-C_6H_4-CH_2 \end{array}$$

and 1-3-5 $C_6H_3Cl_3$, in which the magnitudes of rigid body vibrations and librations and the more prominent modes of internal vibrations are estimated. A summary of this study is given and some simplifying assumptions are discussed. A.R.Stokes

539.2 : 548.7

### 4623 A PROGRAMME FOR REFINING CRYSTAL STRUCTURES ON AN ELECTRONIC COMPUTER.

F.Roche and P.Mériel.

Bull. Soc. Franc. Mineral. Crist., Vol. 82, No. 7-9, 273-6 (July-Sept., 1959). In French.

A programme has been written for an electronic computer for refining the atomic coordinates in a crystal structure by a least squares method. Intensity data for a powder photograph, the approximate atomic positions and the space group are required. Applied to $ZnMn_2O_4$ (space group $D_{4h}^{19}$ = I 41/amd, O in 32(h) positions with $u \cong \frac{1}{4}$ and $v \cong \frac{3}{8}$), two stages of refinement reduced the initial R value from 14% to 8% and then to 5%. In a third refinement variable B values values were introduced but, u, v and B scarcely changed. Each iteration took $1\frac{1}{2}$ min of machine time. A.L.Mackay

539.2 : 548.7

### 4624 THE CRYSTAL STRUCTURE ANALYSIS BY THE SUBSIDIARY MAXIMA OF THE ELECTRON DIFFRACTION PATTERN. N.Uyeda.

Bull. Inst. Chem. Res. Kiyoto Univ., Vol. 35, No. 5-6, 105-22 (Nov., 1957).

A method of determining crystal structures is presented in which measurements of positions of subsidiary maxima, but not their intensities, are used. Its application to $CaBr_2$, a structure with one unknown parameter, is described. (See Abstr. 3912 of 1954). A.R.Stokes

539.2 : 548.7

### 4625 AN ELECTRON DIFFRACTION METHOD FOR DETERMINING THE CRYSTAL LATTICES OF SMALL THIN LAMELLAR PRECIPITATES OCCURRING IN STEELS.

G.R.Booker, J.Norbury and A.M.Rose.

J. Iron Steel Inst., Vol. 193, Pt 3, 221-6 (Nov., 1959).

The precipitates are isolated in an extraction replica and electron diffraction patterns recorded from precipitates with the extraction replica inclined at a number of angles from 90° to 10° to the electron beam. Tilting of the replicas is achieved by using a new stage of simple design or by placing the replicas in small fixed inserts that fit into a standard specimen holder. The various types of two-dimensional spot electron diffraction pattern obtained correspond to different zone axes, and enable the full crystal lattice of the precipitates to be deduced. The technique is particularly valuable for determining crystal lattices of small thin particles for which X-ray diffraction methods fail. Application of the method to plate-like cementite ($Fe_3C$) and iron nitride ($\alpha''$-$Fe_{16}N_2$) precipitates is described.

539.2 : 548.7

### 4626 DENSITY OF THE BONDING ELECTRONS IN DIAMOND.
G.B.Carpenter.

J. chem. Phys., Vol. 32, No. 2, 525-7 (Feb., 1960).

The electron density in diamond, for the bonding electrons only, is derived from old but accurate experimental X-ray diffraction data by subtracting the contribution of the inner shall electrons from the total. The carbon–carbon single bond appears to be very diffuse.

539.2 : 548.7

### 4627 LITHIUM [CRYSTAL DATA].
M.R.Nadler and C.P.Kempter.

Analyt. Chem., Vol. 31, No. 12, 2109 (Nov., 1959).

Spectrographically pure lithium was sealed in a Lindemann glass tube and examined with Co K radiation. The crystal unit cell is cubic body-centred, a = 3.510 04 ± 0.000 41 A at 25°C. The theoretical density is 0.533 $cm^{-3}$. The Li–Li distance for coordination 8 is 3.0398 A. Visual estimates are given of the intensities of the powder lines.

J.Iball

539.2 : 548.7 : 539.214 : 532.7

### ATOMIC DISTRIBUTION IN CRYSTALLINE SULPHUR.
See Abstr. 3517

539.2 : 548.7

### 4628 ANALYSIS OF REAL STRUCTURE OF SINGLE CRYSTALS.
H.Barth.

Z. Elektrochem., Vol. 63, No. 8, 908-12 (1959). In German.

Describes some investigations, by the parallel X-ray beam method, into the texture of crystals of quartz, Si and Ge.

A.R.Stokes

539.2 : 548.7

### 4629 THE CRYSTAL STRUCTURES OF $\alpha$-$V_3S$ AND $\beta$-$V_3S$.
B.Pedersen and F.Grønvold.

Acta cryst., Vol. 12, Pt 12, 1022-7 (Dec., 1959).

The structures of a new, dimorphous vanadium sulphide, $V_3S$, were determined using single-crystal data. $\alpha$-$V_3S$, which is stable above 950° C, has a body-centred tetragonal structure with cell dimensions: a = 9.470, c = 4.589 A. Space group $I\bar{4}2m$ with 8 V in (i) with $x_1 = 0.0932$ and $z_1 = \frac{3}{4}$, 8 V in (i) with $x_2 = 0.2000$ and $z_2 = \frac{1}{4}$, 8 V in (f) with $x_3 = 0.3550$, 8 S in (g) with $x_4 = 0.2851$. $\beta$-$V_3S$, which is stable below 825° C, has a tetragonal structure with cell dimensions: a = 9.381, c = 4.663 A. Space group $P4_2/nbc$ with 8 V in (j) with $x_1 = 0.4080$, 8 V in (j) with $x_2 = 0.2028$, 8 V in (i) with $x_3 = 0.1486$, 8 S in (h) with $x_4 = 0.2171$. (Origin at $\bar{4}$). Besides being closely related to $\beta$-$V_3S$, the structure of $\alpha$-$V_3S$ is closely related to that of $Ni_3P$. The structure of $\beta$-$V_3S$ shows relationships to the $\beta$-W structure type.

539.2 : 548.7

### 4630 THE STRUCTURE ANALYSIS OF A GUINIER–PRESTON ZONE BY MEANS OF A FOURIER METHOD.
K.Doi.

Acta cryst., Vol. 13, Pt 1, 45-9 (Jan., 1960).

The structure of a Guinier–Preston zone in Al-Cu alloy was analysed using a Fourier transformation of the amplitude distribution near the reciprocal lattice point (200). For each atomic plane composing the zone, the content of Cu atoms and the displacement from the net plane of the matrix crystal were determined. The Cu content was found to vanish after the second plane from the origin, giving the zone a quasi-two-dimensional structure. A displacement of about 0.15 A toward the zone origin takes place for the first plane, and displacements for the other planes are found to be negligible. The results are compared with those previously obtained by Toman and by Gerold.

539.2 : 548.7

### 4631 THE CRYSTAL STRUCTURE OF $Zr_4Al_3$.
C.G.Wilson, D.K.Thomas and F.J.Spooner.

Acta cryst., Vol. 13, Pt 1, 56-7 (Jan., 1960).

539.2 : 548.7

### 4632 STRUCTURE-CELL DATA AND EXPANSION COEFFICIENTS OF BISMUTH TELLURIDE.
M.H.Francombe.

Brit. J. appl. Phys., Vol. 9, No. 10, 415-17 (Oct., 1958).

Accurate measurements of the structure-cell parameters of bismuth telluride, $Bi_2Te_3$, have been made using annealed powders and etched rods cut from single-crystal ingots. Previously reported anomalies in the X-ray powder intensity data are found to originate entirely in preferred orientation of the crystallites. A study of the thermal expansion of the unit cell over the temperature range −195 to 400° C has revealed a marked anisotropy between the axial expansion coefficients, that for the c axis ($22.2 \times 10^{-6}$ per °C at 20° C) being almost twice that for the a axis ($12.9 \times 10^{-6}$). Near 200° C changes occur in both the principal axial expansions, comparable with those observed at low temperatures in certain hexagonal metal structures.

539.2 : 548.7

### 4633 THE CRYSTAL STRUCTURE OF AMMONIA MONOHYDRATE.
I.Olovsson and D.H.Templeton.

Acta cryst., Vol. 12, Pt 11, 827-32 (Nov., 1959).

The crystal structure of ammonia monohydrate, $NH_3.H_2O$, was determined from three-dimensional X-ray data. Exposures at −95 and −160°C indicate the same structure. The crystals are orthorhombic (space group $P2_12_12_1$) with four molecules in a unit cell of dimensions: a = 4.51 ± 0.01, b = 5.587 ± 0.003, c = 9.700 ± 0.005 A at −160°C. The structure contains planar chains of water molecules connected by hydrogen bonds of 2.76 A. The chains are crosslinked by the ammonia molecules into a three-dimensional network by short bonds (2.78 A) of the type O–H ··· N and long bonds (3.21, 3.26, 3.29 A) of the type O ··· H–N.

539.2 : 548.7

### 4634 X-RAY STUDY OF SOLID AMMONIA.
I.Olovsson and D.H.Templeton.

Acta cryst., Vol. 12, Pt 11, 832-6 (Nov., 1959).

Ammonia and deutero-ammonia were studied by single-crystal and powder X-ray methods. There are four molecules in the cubic unit cell, and the space group is confirmed to the $P2_13$. The nitrogen parameter obtained by least-squares refinement is equal to 0.0401 for $NH_3$ at −102°C and the same for $ND_3$ at −160°C. Cell dimensions, determined by powder methods, are: a = 5.084 A for $NH_3$ at −196°C, 5.073 A for $ND_3$ at −196°C, 5.091 A for $ND_3$ at −160°C and 5.138 A for $NH_3$ at −102°C. Each ammonia molecule is involved in six hydrogen bonds of approximate length 3.4 A. A possible assignment of the hydrogen atoms to these bonds is given. Electron-density maps give evidence of hydrogen positions with coordinates (0.85, 0.14, 0.99), in agreement with this assignment, but with hydrogen off the bond axis, making the H–N–H angles more nearly tetrahedral.

539.2 : 548.7

### 4635 THE CRYSTAL STRUCTURE OF AMMONIUM CHLORITE AT −35°C.
R.B.Gillespie, R.A.Sparks and K.N.Truebloo

Acta cryst., Vol. 12, Pt 11, 867-72 (Nov., 1959).

The structure of $NH_4ClO_2$ was determined at −35° C, and has been refined by three-dimensional Fourier and least-squares methods. The structure previously published by Levi and Scherilo [Zeitschrift für Kristallographie, Vol. 76, 431 (1931)] is shown to be incorrect. The crystals are tetragonal with space group $P42_1m$, and two molecules in a unit cell of dimensions $a_0 = 6.35$ and $c_0 = 3.78$ A at −35°C. The Cl–O distance in the chlorite ion is 1.57 ± 0.03 A, and the O–Cl–O angle is 110.5 ± 1.4°. Consideration of the known Cl–O distances indicates that the distance decreases as the oxidation number of chlorine increases. Single crystals of ammonium chlorite decompose to crystalline ammonium chloride and ammonium chlorate. The new phases formed are precisely oriented with respect to the original ammonium chlorite.

539.2 : 548.7

### 4636 THE STRUCTURE OF CAESIUM PLUMBO IODIDE $CsPbI_3$.
C.K.Møller.

K. Danske Vidensk. Selsk. mat.-fys. Medd., Vol. 32, No. 1, 18 pp. (1959).

$CsPbI_3$ is obtained from aqueous solutions as yellow, orthorhombic crystals belonging to space group No. 62 Pmnb. The unit cell contains 4 molecules, and a = 4.797 A, b = $10.46_2$ A, c = $17.78_8$ A. Heated to 305-308° C these crystals are transformed into a black modification which has a monoclinically distorted perovskite-like structure: a = b = $6.15_2$ A, c = $6.22_8$ A, $\beta = 88^{\circ}.1_5$. X-ray analysis by Fourier methods of the yellow crystals shows that distorted $PbI_6$ octahedra sharing I atoms form one-dimensional, polynuclear complex ions, $(PbI_3^-)_n$, running parallel to the a-axis. The Pb–I distances vary from 3.01 to 3.42 A. Nine I atoms belonging to three fferent complex ions of this type are nearly di-trigonally arranged ound each Cs atom, with CsI distances 3.87-4.19 A. This structure analogous to that of $M^1CdCl_3$.

539.2 : 548.7

### 4637 THE STRUCTURE OF PEROVSKITE-LIKE CAESIUM PLUMBO TRIHALIDES.
C.K.Møller.

K. Danske Vidensk. Selsk. mat.-fys. Medd., Vol. 32, No. 1, 27 pp. 959).

Crystalline compounds of composition $CsPbX_3$, where X = Cl or r, may be prepared either from aqueous solutions or by fusing sX and $PbX_2$. The pale yellow $CsPbCl_3$ has cubic perovskite ructure above 47° C (a = 5.605 A), the orange-coloured $CsPbBr_3$ ove 130° C (a = 5.874 A). Below these temperatures the structures re slightly distorted, but apparently without changes of volume at e transition points. $CsPbBr_3$ below 130° C (and possibly also $sPbCl_3$ below 47° C) exhibits a superstructure, but not above this mperature. Application of Fourier methods shows that above, as ell as below, the transition points, both the halogen atoms and the s atoms are a little displaced from those positions expected for an deal perovskite structure. Structure factors have been calculated the assumption that each halogen atom occupies one of four, each s atom one of six, close-lying potential-minima at random; they now excellent agreement with the observed structure factors. It is uggested that such a delocalization of certain atoms may be a ommon feature in cubic perovskite structures where the tolerance actor t ≠ 1. The PbCl distances are 2.86 A and the PbBr distances .99 A, i.e. considerably shorter than the sum of the corresponding nic radii.

539.2 : 548.7

### 4638 THE CRYSTAL STRUCTURE OF $Ce_2Ni_7$.
D.T.Cromer and A.C.Larson.

Acta cryst., Vol. 12, Pt 11, 855-9 (Nov., 1959).

The unit cell is hexagonal, probable space group $P6_3/mmc$, with a = 4.98 ± 0.02, c = 24.52 ± 0.08 A, and contains four formula units. The structure consists of double layers of the $CeNi_5$ structure $CaCu_5$ type) alternating with double layers of the $CeNi_2$ structure $Cu_2Mg$ type). Relationships between this structure, the $CeNi_3$, and $PuNi_3$ structures, the fundamental $MX_5$ structure and the three Laves or Friauf phases are discussed in detail.

539.2 : 548.7

### 4639 THE CRYSTAL STRUCTURE OF $CoCl_2{\cdot}6H_2O$.
J.Mizuno, K.Ukei and T.Sugawara.

J. Phys. Soc. Japan, Vol. 14, No. 3, 383 (March, 1959).

The structure of $CoCl_2.6H_2O$ has been determined by single crystal methods using two-dimensional Patterson and Fourier syntheses. The crystals are monoclinic with a = 10.34, b = 7.06, c = 6.67 A, $\beta$ = 122° 19'; space group = $C^3_{2h}$ − C2/m; 2 formula units per unit cell. Atomic coordinates are (x,y,z) Co (0,0,0), 4 Cl (0.278, 0, 0.175), 8 O (0.029. ± 0.221, 0.255), 4 O (0.275, 0, 0.700). Two $Cl^-$ ions and 4 $H_2O$ molecules are octahedrally coordinated to the $Co^{2+}$ ion to form the group ($CoCl_2.4H_2O$) with 2 $H_2O$ molecules uncoordinated to cobalt. J.Iball

539.2 : 548.7

### 4640 STRUCTURE OF TETRACOBALTDODECARBONYL.
P.Corradini.

J. chem. Phys., Vol. 31, No. 6, 1676-7 (Dec., 1959).

Space-group Pccn, 4 molecules per cell, a = 11.7, b = 8.9, c = 17.1 A. Atomic coordinates are given. A.R.Stokes.

539.2 : 548.7

### 4641 THE CRYSTAL STRUCTURE OF THE CUPROUS CHLORIDE AZOMETHANE COMPLEX.
I.D.Brown and J.D.Dunitz.

Acta cryst., Vol. 30, Pt 1, 28-34 (Jan., 1960).

The structure was determined by an X-ray analysis in which the final parameters were evaluated from a least-squares treatment of the three-dimensional data. The crystal are triclinic, a = 6.87, b = 7.03, c = 3.82 A, $\alpha$ = 97° 7', $\beta$ = 95° 15', $\gamma$ = 111° 45'; space group $P\bar{1}$, with one formula unit ($Cu_2Cl_2.C_2H_6N_2$) in the unit cell. The complex contains infinite copper-chlorine chains (Cu—Cl : 2.35 A), running parallel to the c axis, which are joined in pairs by weaker copper—chlorine bonds (2.55 A). The chains are further linked through trans-azomethane molecules by $\sigma$-type copper—nitrogen bonds (1.99 A), which complete a distorted tetrahedral coordination around each copper atom.

539.2 : 548.7

### 4642 THE CRYSTAL STRUCTURE OF $ISbCl_8$ AND $IAlCl_6$.
C.G.Vonk and E.H.Wiebenga.

Acta cryst., Vol. 12, Pt 11, 859-66 (Nov., 1959).

$ISbCl_8$ crystallizes in the space group $P4_1$, with four units $ISbCl_8$ per cell. The coordinates of the Sb and I atoms were found from the [010] Patterson synthesis. Approximate coordinates of the chlorine atoms were obtained by the heavy atom technique. The coordinates were refined by successive Fourier syntheses of the [010] projection. The structure consists of $ICl_2^+$ and $SbCl_6$ ions, which are linked to chains by weak covalent bonds. $IAlCl_6$ crystallizes in the space group $P2_1$ with two units $IAlCl_6$ per cell. The positions of the I atoms were found from Patterson syntheses of the main projections. The positions of the Cl atoms were again determined by the heavy-atom method. This structure consists of chains in which $ICl_2^+$ and $AlCl_4^-$ ions alternate.

539.2 : 548.7

### 4643 THE CRYSTAL STRUCTURE OF IRON (II) CHLORIDE TETRAHYDRATE.
B.R.Penfold and J.A.Grigor.

Acta cryst., Vol. 12, Pt 11, 850-4 (Nov., 1959).

The crystal structure was determined by means of electron-density projections down the three crystallographic axes. Atomic coordinates have been refined by three-dimensional least-squares treatment of the diffraction data of the three equatorial zones. The crystals are monoclinic, space group $P2_1/c$ with a = 5.91, b = 7.17, c = 8.44 A, $\beta$ = 112° 10'. The structure consists of discrete $Fe(H_2O)_4Cl_2$ groups, two per unit cell. They are distorted octahedra and it is suggested that they are held together by O—H ... Cl hydrogen bonds. Bond distances within a group are Fe—Cl, 2.38; Fe—O(1), 2.09; Fe—O(2), 2.59 A.

539.2 : 548.7

### 4644 THE CRYSTAL STRUCTURES OF POTASSIUM PENTABORATE, $K_2O.5B_2O_3$, AND THE ISOMORPHUS RUBIDIUM COMPOUND.
J.Krogh-Moe.

Ark. Kemi, Vol. 14, Paper 39, 439-49 (1959).

The crystal structures were determined by three-dimensional Fourier synthesis based on experimental data from single crystal Weissenberg exposures. The basic unit of the structure is a double ring consisting of one $BO_4$ tetrahedron and four $BO_3$ triangles. The double rings connect to helix chains which again connect with four neighbouring chains, thus forming a three-dimensional framework. The structure contain two such three-dimensional frameworks, which are separate and interlocking.

539.2 : 548.7

### 4645 THE CATION DISTRIBUTION IN SOME CRYSTALLINE AND VITREOUS CESIUM BORATES.
J.Krogh-Moe.

Ark. Kemi, Vol. 14, Paper 40, 451-9 (1959).

From single crystal X-ray Weissenberg exposures, Patterson functions were derived for caesium triborate, caesium pentaborate and caesium enneaborate. Radial distribution curves for three caesium borate glasses containing 4.6, 10.7 and 20.9 mole per cent caesium oxide were determined, using X-ray scattering intensities. These data permitted a comparison of the shortest Cs—Cs interatomic separation in the various glass and crystalline phases. It was found that the glass has a shortest average Cs—Cs separation of about 4.6 A, which remains fairly constant within a large composition interval. This led to the conclusion that the Cs atoms are not randomly distributed in the glass.

539.2 : 548.7

### 4646 SEMICONDUCTING MIXED CRYSTALS OF THE TYPE $(A^{I}_{X/2}\ B^{IV}_{(1-x)}\ C^{V}_{X/2})D^{VI}$
H.Fleischmann, O.G.Folberth and H.Pfister.

Z. Naturforsch., Vol. 14a, No. 11, 999-1000 (Nov., 1959). In German.

The example investigated was $(Ag_{X/2}\ Pb_{(1-x)}\ Bi_{X/2})Te$ and this was found to have the NaCl structure, the lattice parameter varying linearly with composition. The thermal conductivity passed through a minimum value of only 0.005 W $cm^{-1}$ $deg^{-1}$ which, associated with an electrical conductivity of 300 ohm cm, could be of interest for thermoelectric applications. K.W.Plessn

539.2 : 548.7

### 4647 CRYSTALLOGRAPHIC STUDIES ON SODIUM URANYL-8-QUINOLINATE, $Na.UO_2.(C_9H_6NO)_3$.
V.Amirthalingam.

Acta cryst., Vol. 13, Pt 1, 61 (Jan., 1960).

539.2 : 548.7

### 4648 THE CRYSTAL STRUCTURE OF $Ti_2Ni$.

G.A.Yurko, J.W.Barton and J.G.Parr.

Acta cryst., Vol. 12, Pt 11, 909-11 (Nov., 1959).

The crystal structure was determined from powder specimens. The unit cell is face-centred cubic with 96 atoms and dimension a = 11.278 ± 0.001 A at 21°C. The space group is $O_h^7$-Fd3m. 64 titanium atoms are in positions 48f and 16c, and 32 nickel atoms are in positions 32c. The atomic parameters, $X_{Ni} = 0.215 \pm 0.001$ and $X_{Ti} = 0.810$, were determined by trial and error.

539.2 : 548.7

### 4649 THE CRYSTAL STRUCTURE OF PURE [EDEL-] AMBLYGONITES, $LiAlPO_4(OH,F)$.

W.H.Baur.

Acta cryst., Vol. 12, Pt 12, 988-94 (Dec., 1959). In German.

The structure of clear, transparent crystals of amblygonite, $LiAlPO_4(OH,F)$, from a pegmatite in Newry, Maine was solved by Patterson projections on [100] and [001] and refined by Fourier and $(F_o - F_c)$-projections on these zones. The final R-values are: R[100] = 9.8%; R[001] = 10.7%. The structure formula may be written as:

$$^3_\infty Li^{[4O+1OH,F]}Al^{[4O+2OH,F]}PO_4(OH,F).$$

Space group: $P\bar{1}$. Cell constants: a = 5.18, b = 7.15, c = 5.04 A; $\alpha = 112^\circ\ 07'$, $\beta = 97^\circ\ 48'$, $\gamma = 67^\circ\ 53'$. The results are compared with the work of Simonow and Bjelow on amblygonite of poorer quality. It turns out that both structures are very similar but show marked differences in their atomic parameters. These differences are beyond the experimental errors, they are "highly significant". In this work Li is found to occupy only one position, which has the coordination number 5. In the work of Simonow and Bjelow, Li is found to occupy within the same cavity at random two different positions which are separated by 0.5 A. There exists the possibility that the crystal from Maine is a low-temperature form, and the poorer crystallized specimen is a high-temperature form of amblygonite.

539.2 : 548.7

### 4650 THE PHYSICAL PROPERTIES OF CRYSTALS CONTAINING ATOMS WITH ELECTRONS IN THE "d" VALENCY STATE (PYRITE, HAUERITE, HAEMATITE, RUTILE AND VANADIUM PENTOXIDE).

F.Sgarlata.

R.C. Ist. Super Sanita, Vol. 22, Pt 8-9, 851-76 (1959). In Italian.

Structural parameters were determined using an Mo-filter in order to reduce background radiation. Atomic distances were obtained: $FeS_2$, Fe–S = 2.264 A, S–S = 2.178, 3.075, 3.322 A; $MnS_2$, Mn–S = 2.593 A, S–S = 2.071, 3.765, 3.570 A; $Fe_2O_3$, Fe–O = = 1.958, 2.090 A, Fe–Fe = 2.874, 2.963 A. From a study of the results it is imputed that in hauerite ($MnS_2$) the 3d orbital of sulphur is employed. The bond is covalent in haematite and partially ionic in rutile. In vanadium pentoxide there is a double covalent bond with a distance of 1.54 A which is smaller than in $VOSO_4.5H_2O$ (1.67 A).

J.M.Hough

539.2 : 548.7

### 4651 THE CRYSTAL STRUCTURE OF ZUNYITE.

W.B.Kamb.

Acta cryst., Vol. 13, Pt 1, 15-24 (Jan., 1960).

The structure proposed by Pauling for the rare aluminosilicate mineral zunyite $[Al_{13}(OH)_{18}Si_5O_{20}Cl]$ has been confirmed and refined with the use of 163 hk0 reflections and 409 hh*l* reflections obtained with Mo K$\alpha$ radiation from single-crystal Weissenberg photographs. The structure is isometric ($T_d^2$) and is built up of $Si_5O_{16}$ groups of linked silicon tetrahedra combined with $Al_{12}O_{16}(OH)_{30}$ groups of linked aluminium octahedra. Refinement is carried out independently for the hk0 and hh*l* data, and the final reliability factors are 0.12 for both sets of data. Positional parameters are refined by the least-squares method, and isotropic temperature parameters for separate atoms are adjusted with the help of difference syntheses. The refined structure differs from the trial structure by distortion of coordination polyhedra in a fashion similar to the distortions in related structures. The interatomic distance Al–O of 1.80 ± 0.016 A is derived for tetrahedrally coordinated aluminium. The averaged Si–O distance is 1.64 ± 0.01 A. The arrangement of protons in the structure is deduced from structural arguments. The proposed arrangement requires the inclusion of at least two fluorine atoms per stoichiometric molecule, modifying the chemical formula to $(OH, F)_{16}F_2Al_{13}Si_5O_{20}Cl$ and explaining the importance of fluorine in the formation of zunyite.

539.2 : 548.7

### 4652 ACCURACY OF ATOMIC POSITIONS IN THE ZUNYITE STRUCTURE.

W.B.Kamb.

Acta cryst., Vol. 13, Pt 1, 24-7 (Jan., 1960).

The accuracy of positional parameters in the refined zunyite structure is estimated by four different statistical methods, including a comparison of two entirely independent refinements of the structure. The estimates show tolerable agreement, but disagree as to the importance of $F_o$ measurement error in affecting the parameter error. Reliable estimates of ±0.008 A (standard deviation) for oxygen coordinates and ±0.003 A for silicon and aluminium coordinates are obtained.

539.2 : 548.7

### 4653 THE CRYSTAL STRUCTURE OF BIS-SALICYLALDIMINATO-NICKEL (II) AND -COPPER (II).

J.M.Stewart and E.C.Lingafelter.

Acta cryst., Vol. 12, Pt 11, 842-5 (Nov., 1959).

The crystal structure of bis-salicylaldiminato-nickel (II) was determined by 2-dimensional projections, and the -copper (II) compound was shown to be isomorphous. The cell dimensions of the nickel compound are $a_0 = 12.96$, $b_0 = 5.83$, $c_0 = 8.11$ A, $\beta = 95^\circ 35'$, Z = 2. The space group os $P2_1/c$. The molecule is found to be planar (standard deviation = 0.022 A) and to have a trans configuration.

539.2 : 548.7

### 4654 THE CRYSTAL STRUCTURE OF THE TRANS ISOMER OF $\beta$-IONYLIDENE CROTONIC ACID.

E.L.Eichhorn and C.H.MacGillavry.

Acta cryst., Vol. 12, Pt 11, 872-83 (Nov., 1959).

The crystal structure of a $\beta$-ionylidene crotonic acid, prepared by Arens and Van Dorp (1946) was determined and refined three-dimensionally. The conjugated side-chain is all-trans; since this acid was a step in the vitamin A synthesis by Arens and Van Dorp, it can be assumed that the corresponding part of the vitamin A molecule is also all-trans.

539.2 : 548.7

### 4655 THE CRYSTAL STRUCTURE OF NITROBENZENE AT −30°C.

J.Trotter.

Acta cryst., Vol. 12, Pt 11, 884-8 (Nov., 1959).

Crystals of nitrobenzene at −30°C, are monoclinic, space group $P2_1/c$, with four molecules in the unit cell. The structure was determined from the projection along the short $\alpha$-axis, and refined by three-dimensional differential syntheses. The molecule is exactly planar, and values of the bond lengths, valency angles, and intermolecular distances are given.

539.2 : 548.7

### 4656 A REFINEMENT OF THE 1:12-BENZPERYLENE STRUCTURE.

J.Trotter.

Acta cryst., Vol. 12, Pt 11, 889-92 (Nov., 1959).

The structure of 1:12 benzperylene, $C_{22}H_{12}$, was refined by two-dimensional $(F_o - F_c)$ syntheses, and the measured bond lengths compared with those derived by valance-bond and molecular-orbital calculations.

539.2 : 548.7

### 4657 CRYSTAL STRUCTURE OF 9-CYANO-ANTHRACENE.

H.Rabaud and J.Clastre.

Acta cryst., Vol. 12, No. 11, 911-15 (Nov., 1959). In French.

The structure was determined from rotation and retigraph diagrams. The space group is $P2_12_12_1$, axial lengths a = 17.1, b = 15.1, c = 3.93 A; four molecules per cell, X-ray density 1.30 g cm$^{-3}$. All carbon and nitrogen positions were determined. The anthracene portion of the molecule is found deformed from regularity in a very similar way as in anthracene. The CN group has normal internal CN distance (1.15 A) and lies rather close to the central C of the anthracene group (CC = 1.43 A). The isomorphous Br-9-methyl-10-anthracene is under study.

539.2 : 548.7

### 4658 THE CRYSTAL STRUCTURES OF SOME ANTHRACENE DERIVATIVES. VI. 9-ANTHRALDEHYDE.

J.Trotter.

Acta cryst., Vol. 12, Pt 11, 922-8 (Nov., 1959).

For Pt IV, dealing with 9 : 10 dinitroanthracene, and Pt V, dealing with 9-nitroanthracene, see Acta cryst., Vol. 12, Pt 3, 232, 237 (March, 1959). Crystals of 9- anthraldehyde are orthorhombic, space group $P2_12_12_1$, with four molecules in the unit cell. The structure was determined from the projection along the short a-axis, and refined by three-dimensional differential syntheses. The anthracene skeleton is completely planar, but not coplanar with the plane of the aldehyde group, the angle between the planes being 27°.

539.2 : 548.7

### 4659 THE CRYSTAL AND MOLECULAR STRUCTURE OF 4,4'-DICHLORODIPHENYL SULFONE.

.Sime and S.C.Abrahams.

ta cryst., Vol. 13, Pt 1, 1-9 (Jan., 1960).

The crystals are monoclinic, space group I2/a, with a cell ving a = 20.204 ± 0.010, b = 5.009 ± 0.010, c = 12.259 ± 0.010 A, 90° 34' ± 15', and containing four molecules. The crystal struc- e was solved by two-dimensional Patterson and by trial-and-error ethods. The position and thermal vibration parameters were initi- y refined by use of double Fourier series. Final refinement was ained by a complete anisotropic least-squares analysis of the 58 unobserved structure factors. The three position and six therm- parameters of all atoms except hydrogen have been determined. e bond distances of interest include S—C = 1.765 ± 0.006, -O = 1.432 ± 0.005, C—C = 1.380 ± 0.003, Cl—C = 1.736 ± 0.007 A; ong the bond angles are C—S—O = 107° 39' ± 17', -S—C = 104° 48' ± 24', O—S—O = 120° 24' ± 25'. The dihedral gle between the planes of the aromatic rings is 79° 27' ± 18' and tween the plane of each ring and the common C—S—C plane it is ° 25' ± 18'.

539.2 : 548.7

### 4660 A STUDY OF 4,4'-DICHLORO DIPHENYL SULPHONE BY NEUTRON DIFFRACTION.

E.Bacon and N.A.Curry.

ta cryst., Vol. 13, Pt 1, 10-14 (Jan., 1960).

A Fourier and least-squares analysis of the intensities of the reflections from a single crystal provided measurements of the -H bond and anisotropic temperature factors for the hydrogen oms. The motion of the latter were analysed tentatively in terms molecular oscillation and bending and stretching vibrations, with ro-point energy, of the C—H bonds.

539.2 : 548.7

### 4661 THE CRYSTAL STRUCTURE OF $\beta$-GLYCINE.

Y.Iitaka.

ta cryst., Vol. 13, Pt 1, 35-45 (Jan., 1960).

The crystal structure of the unstable form of glycine, $\beta$, was termined. The structure was refined by Fourier methods using e $(h0l)$ and $(0kl)$ data obtained by Geiger counter measurements. e crystals are monoclinic with space group $P2_1$ and the unit-cell mensions are a = 5.077, b = 6.268, c = 5.380 A; $\beta$ = 113.2°. The ructure consists of hydrogen-bonded molecular layers, extending rallel to the (010) plane, which have the same configuration of olecules as that found in the $\alpha$-form. The two forms differ in their drogen bond systems between layers.

539.2 : 548.7

### 4662 CRYSTALLOGRAPHIC DATA FOR 5-OXIPHENAZINE.

R.Curti and V.Riganti.

cta cryst., Vol. 13, Pt 1, 55-6 (Jan., 1960).

539.2 : 548.7

### 4663 INSULIN...PRELIMINARY X-RAY STUDIES OF TWO TYPES OF SULPHATE CRYSTALS.

.W.Low and C.B.Shoemaker.

cta cryst., Vol. 12, Pt 11, 893-6 (Nov., 1959).

Preparations of beef insulin sulphate crystals yield two crystal- ne forms. Both are orthphombic, space group $P2_12_12_1$, and both sually give the same air-dried form. The morphology, optics, and nit-cell dimensions are described. The two-dimensional Patterson rojections for both forms are presented.

539.2 : 548.7

### 4664 STRUCTURE OF POLY-L-PROLINE II.

V.Sasisekharan.

cta cryst., Vol. 12, Pt 11, 897-903 (Nov., 1959).

The structure of poly-L-proline is completely worked out by -ray and optical diffraction methods. The polymer chains are rranged in a hexagonal cell with a = 6.68 and c = 9.36 A. The space roup is $P3_2$. The coordinates of the atoms were determined by ccurate graphical methods. The correctness of the structure was as also verified by intensity calculations. For this arrangement f the polymer chains, there are the least number of short con- acts, the only one which occurs being a C-H...O hydrogen bond. From packing considerations also the structure arrived at is seen o be the best.

539.2 : 548.7

### 4665 STRUCTURE OF POLY-L-HYDROXYPROLINE A.

V.Sasisekharan.

cta cryst., Vol. 12, Pt 11, 903-9 (Nov., 1959).

The structure of poly-L-hydroxyproline A is worked out from X-ray powder and oriented film patterns. The polymer chains are packed in a hexagonal lattice with a = 12.3 and c = 9.15 A. The space group is $P3_2$. The arrangement of the chains is shown to be very similar to that of poly-L-proline II (see preceding abstract). It is also shown that the fundamental unit of the structure requires three helices as in collagen. The correctness of the structure was also verified by intensity calculations. The agreement between the calculated and observed intensities is good. No further refinement is carried out in the absence of accurate intensity data.

539.2 : 548.7

### 4666 X-RAY DIFFRACTION STUDY OF THE HEAT TREATMENT OF KAOLINITE. G.B.Mitra.

Indian J. Phys., Vol. 31, No. 6, 324-8 (June, 1957).

539.2 : 548.7

### 4667 EVIDENCE FOR DISTINCT SECTORS IN POLYMER SINGLE CRYSTALS.

D.C.Bassett, F.C.Frank and A.Keller.

Nature (London), Vol. 184, 810-11 (Sept. 12, 1959).

Polyethylene can have a paraffin-like crystal habit which consists of thin lozenge-shaped layers with each segment of a folded molecular chain normal or nearly normal to the plane of the layers. It has been suggested that the molecules might fold in the plane of the growing faces, which are of the {110} type in the purely lozenge-shaped crystals. In the four different quadrants the chains are then folded along four different <110> directions: the apparent single crystal thus consists of four structurally distinct sectors in twin relation. Evidence from electron diffraction and electron micrographs is discussed which establishes the existence of distinct sectors within the same crystal. R.F.Barrow

539.2 : 548.7

### 4668 GENERAL CONSIDERATIONS ON THE STRUCTURE OF CRYSTALLINE POLYHYDROCARBONS.

G.Natta and P.Corradini.

Nuovo Cimento Suppl., Vol. 15, No. 1, 9-39 (1960).

539.2 : 548.7

### 4669 STRUCTURE AND PROPERTIES OF ISOTACTIC POLYPROPYLENE. G.Natta and P.Corradini.

Nuovo Cimento Suppl., Vol. 15, No. 1, 40-51 (1960).

539.2 : 548.7

### 4670 CRYSTAL STRUCTURE OF ISOTACTIC POLY-ALPHA-BUTENE. G.Natta, P.Corradini and I.W.Bassi.

Nuovo Cimento Suppl., Vol. 15, No. 1, 52-67 (1960).

539.2 : 548.7

### 4671 CRYSTAL STRUCTURE OF ISOTACTIC POLYSTYRENE.

G.Natta, P.Corradini and I.W.Bassi.

Nuovo Cimento Suppl., Vol. 15, No. 1, 68-80 (1960).

539.2 : 548.7

### 4672 CRYSTAL STRUCTURE OF POLY-ORTHO-FLUOROSTYRENE. G.Natta, P.Corradini and I.W.Bassi.

Nuovo Cimento Suppl., Vol. 15, No. 1, 83-95 (1960).

539.2 : 548.7

### 4673 CRYSTAL STRUCTURE OF POLY-ORTHO-METHYLSTYRENE. P.Corradini and P.Ganis.

Nuovo Cimento Suppl., Vol. 15, No. 1, 96-103 (1960).

539.2 : 548.7

### 4674 CRYSTAL STRUCTURE OF POLY-ALPHA-VINYLNAPHTALENE. P.Corradini and P.Ganis.

Nuovo Cimento Suppl., Vol. 15, No. 1, 104-10 (1960).

539.2 : 548.7

### 4675 THE CRYSTAL STRUCTURE OF CIS 1,4 POLY-BUTADIENE. G.Natta and P.Corradini.

Nuovo Cimento Suppl., Vol. 15, No. 1, 111-21 (1960).

539.2 : 548.7

### 4676 INFRARED SPECTRA OF STEREO-ORDERED POLYMERS OF MONOMERIC VINYL AROMATICS.

I. ISOTACTIC POLYSTYRENE.

D.Morero, E.Mantica, F.Ciampelli and D.Sianesi.

Nuovo Cimento Suppl., Vol. 15, No. 1, 111-35 (1960). In Italian.

539.2 : 548.7

4677 INFRARED SPECTRA OF POLYBUTADIENE. I. SYNDIOTACTIC 1,2 POLYBUTADIENE.
D.Morero, E.Mantica and L.Porri.
Nuovo Cimento Suppl., Vol. 15, No. 1, 136-47 (1960). In Italian.

539.2 : 548.7

4678 SUMMARIZED PROCEEDINGS OF A CONFERENCE ON PRECIPITATION IN ALLOYS AND ON METAL STRUCTURES — LONDON, NOVEMBER 1958.
A. Franks and R.S.M.Revell.
Brit. J. appl. Phys., Vol. 10, No. 10, 438-44 (Oct., 1959).

A joint conference of the X-ray Analysis Group and the Electron Microscopy Group of the Institute of Physics.

## VARIOUS SOLID STRUCTURES

539.213

4679 INFRARED REFLECTION SPECTRA OF CRYSTALLIZATION PRODUCTS OF CERTAIN GLASSES OF THE $Na_2O—SiO_2$ SYSTEM. Yu.V.Glazkov.
Optika i Spektrosk., Vol. 4, No. 3, 400-2 (1958). In Russian.
English summary: PB 141047T-4, obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

Glasses with differing $Na_2O:SiO_2$ ratios were given thermal treatments at 1060°C and 620°C. Measurements of the reflection spectra (7-23 μ), indicated that only those glasses with the stochiometric compositions of sodium metasilicate and sodium bisilicate retain their chemical composition after crystallization. For the other glasses there is a tendency for higher silicates to separate out.
D.L.Greenaway

539.213

4680 STUDY OF VITRIFICATION BY A LUMINESCENCE METHOD.
E.V.Anufrieva, M.V.Vol'kenshtein and T.V.Razgovorova.
Optika i Spektrosk., Vol. 4, No. 3, 414-15 (1958). In Russian.
English summary: PB 141047T-4 obtainable from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., U.S.A.

Thin films of polyvinyl plastics containing small amounts of luminescent dyes showed a sharp break in their temperature—fluorescence curve at the vitrification temperature, though with some hysteresis in cycles of heating and cooling. No break occurred for auramine in ethyl cellulose in the range studied (20-100°C).
S.T.Henderson

539.214

4681 X-RAY STUDY OF THE ACTION OF HEAT ON THE STRUCTURAL STATE OF A POLYTHENE IRRADIATED UNDER VACUUM BY $\gamma$-RAYS. Y.de Zarauz.
C.R. Acad. Sci. (Paris), Vol. 249, No. 15, 1348-50 (Oct. 12, 1959). In French.

No change of structure takes place until the dose attains 150 mr Heating produces a reduction in the crystallinity originally induced by radiation, but has no effect on the curve relating the a-parameter of the orthorhombic cell with temperature, even though this curve differs for irradiated and non-irradiated samples.
B.T.M.Willis

539.214 : 539.2 : 548.7 : 532.7

ATOMIC DISTRIBUTION IN PLASTIC SULPHUR.
See Abstr. 3517

539.215 : 621.317.79

4682 MULTI-CHANNEL PHOTOELECTRIC SCANNING INSTRUMENT FOR SIZING MICROSCOPIC PARTICLES.
B.B.Morgan and E.W.Meyer.
J. sci. Instrum., Vol. 36, No. 12, 492-501 (Dec., 1959).

Development of a photoelectric scanning instrument for counting and sizing particles dispersed on a microscope slide has continued and the performance of a five-channel version has been assessed. The size distributions of a number of fractions of coal particles of sizes down to 1.5 μ determined by the instrument agree (to within 15%) with those from visual counts. Comparative sizings are given also of alumina particles (5 to 20 μ) and of transparent profiles in an opaque film (5 to 20 μ). Comparative counts are given of the number of particles 1 to 5 μ in thermal precipitator samples of coal. Data are presented on the reproducibility of instrument sizings and an indication is given of the time needed for a determination.

539.217

4683 ABSORPTION OF SODIUM AND ARGON BY GLASS.
J.W.Wheeldon.
Brit. J. appl. Phys., Vol. 10, No. 6, 295-8 (June, 1959).

The rate of absorption of sodium increases rapidly with temperature and is linear with time at a constant temperature. Ionization of the sodium does not change the rate of absorption. Micro-section show that the absorbed sodium forms a layer of apparently uniform sodium concentration which advances through the glass with a sharp front. The concentration of sodium in this layer was found to be as high as $2 \times 10^{22}$ atoms $cm^{-3}$ in one case. Argon is only absorbed when ionized and the rate of absorption is more or less independent of temperature below 300°C. The argon does not diffuse through the glass and is partially evolved when heated to over 350°C.

539.219

4684 USING THE $C^{14}$ ISOTOPE FOR FINDING THE SOLUBILITY OF CARBON IN ALPHA-IRON. B.I.Bruk.
Dokl. Akad. Nauk SSSR, Vol. 128, No. 4, 709-12 (Oct. 1, 1959). In Russian.

Suggests that the wide variation in experimental figures for the solubility in question is due to lack of precision in the definition of the term solubility, i.e. is due to the absence of criteria as to how much carbon goes into actual solution and how much is merely concentrated at lattice defects. An experimental method is describe for finding the true solubility at 620, 640, 680 and 700°C, using radioactive $C^{14}$ and either the radiometric layer analysis method or autoradiography. Extrapolation to the temperature of eutectoid transformation yields 0.035% as the maximum solubility.
D.E.Brow

539.21

4685 THE THERMODYNAMICS OF SOLID SOLUTIONS OF SOME SEMICONDUCTING SYSTEMS.
V.N.Romanenko and V.I.Ivanov-Omskii.
Dokl. Akad. Nauk SSSR, Vol. 129, No. 3, 553-5 (Nov. 21, 1959). In Russian.

Experimental data on the phase diagrams are compared with calculations made on near-regular solutions. There is agreement for Ge—Si, using mixing energy $V = +2200$ cal/mol. Between the melting points of Ge and Si, $|\tilde{V}|$ $(= V/(RT))$ is between 0.90 and 0.64. The criterion for solid solution is $|\tilde{V}| \leq 2$. Poorer agreement is found for InSb—GaSb.
R.Berman

539.219

4686 SUBSTRUCTURE OF THE GRAINS OF DEFORMED ALUMINIUM-MAGNESIUM ALLOYS.
V.I.Syutkina and É.S Yakoleva.
Fiz. Metallov i Metallovedenie, Vol. 6, No. 2, 326-33 (1958). In Russian.

Results of the research which was carried out with Al containing 0.00, 0.01, 0.04, 0.10, 0.30 and 0.92% Mg, 0.001% Fe, 0.0014% Si, 0.0011% Cu and traces of Zn and Mn (mean grain size of initial specimens 0.1 mm) showed that the grains of deformed Al-Mg alloys have a complex substructure comprising large disorientated regions and less-disoriented small fragments. The alloying of Al with Mg reduces the size of the latter, while increasing both the number and degree of disorientation of the former. This is explained as being due to the lattice distortions being blocked by Mg atoms and the increase of non-uniform stresses in the grains.
F.Lachman

539.219

4687 THEORY OF COALESCENCE OF SOLID SOLUTIONS.
I.M.Lifshits and V.V.Slezov.
Fiz. tverdogo Tela, Vol. 1, No. 9, 1401-10 (Sept., 1959). In Russian.

Theoretical. Discusses the effect of various factors such as elastic stress arising during seed growth, grain anisotropy, collisions between grains etc., on the process of diffusion decay in a supersaturated solid solution. It is shown that account of all these factors tends merely to a redistribution of certain parameters entering into the theory and gives no system of asymptotes for the distribution of grains with respect to size. The system of asymptotes derived in the authors' earlier paper (Abstr. 2956 of 1959) therefore takes on a universal character.
C.R.S.Manders

539.219

### 4688 THERMODYNAMIC PROPERTIES OF BINARY ALLOYS EXHIBITING MISCIBILITY IN SOLID AND LIQUID ASES.

R.P.Rastogi and K.T. Rama Varma.

c. Indian Acad. Sci. A, Vol. 48, No. 6, 336-43 (Dec., 1958).

Excess thermodynamic functions are computed from the phase gram of nickel-manganese alloys exhibiting complete miscibility olid and liquid phases. A method is outlined for testing the rnal consistency of the data. Heat of mixing of solid and liquid ys is found to be similar. It is concluded that the redistribution alence electrons in the alloy is responsible for the negative heat of ing.

539.219

### 4689 CONFIGURATIONAL PARTITION FUNCTION OF SOLID SOLUTIONS.

T.S.Chang.

ence Record (China), New Series, Vol. 3, No. 1, 27-30 (Jan., 1959).

Some further considerations are given about the approximation thod described in Abstr. 6441 (1958), in particular the extension he quasichemical formula to include triple clusters in binary d solutions for the face-centred lattice. J.Hawgood

539.23

### 4690 TECHNIQUE FOR PREPARING THIN FILMS OF $\alpha$-IRON.

D.G.Brandon and J.Nutting.

it. J. appl. Phys., Vol. 10, No. 6, 255-6 (June, 1959).

A technique is described for preparing foils of $\alpha$-iron which are itable for direct-transmission examination in an electron micro-ope. While there is no guarantee that a particular point on the foil ll be thin enough for examination, results show that the technique oduces foils enabling localized effects to be observed.

539.23

### 4691 EVAPORATION OF METALS BY ELECTRON BOMBARDMENT.

O.S.Heavens.

sci. Instrum., Vol. 36, No. 2, 95-9 (Feb., 1959).

The rate of deposition of films of several metals, evaporated maintaining a pendant molten drop by electron bombardment, found in most cases to agree with that expected on kinetic theory. e analysis enables the usefulness of the method for other metals be judged.

539.23

### 4692 PREPARATION OF THIN SELF-SUPPORTING CARBON FILMS.

G.Dearnaley.

ev. sci. Instrum., Vol. 31, No. 2, 197-8 (Feb., 1960).

The method is for thicknesses between 4 $\mu g/cm^2$ and 1 mg/cm d areas up to 1.5 $cm^2$. These have many applications as targets d backings, and have been used as beam strippers in the Harwell andem Generator.

539.23 : 533.5

### 4693 A SIMPLE DOSE APPARATUS FOR VACUUM DEPOSITION.

H. Strosche.

. angew. Phys., Vol. 11, No. 11, 441-3 (Nov., 1959). In German.

Describes a method of controlling the quantity of cadmium sele-ide deposited in a thin film by heating pellets of the two metals. J.M.Hough

539.23

### 4694 ON THE STRUCTURE OF EVAPORATED CARBON FILMS.

J.Gjønnes.

cta Cryst., Vol. 13, Pt 1, 54-5 (Jan., 1960).

Electron diffractograms of evaporated carbon films, of thickness 00-600 A were analysed. The observed interatomic distances do t fit well with a planar hexagonal layer, and the nearest neighbour istance (1.45 A) is appreciably greater than that found in graphite .42 A). Good fit is obtained with the radial distribution curve of three-dimensional network consisting of 6-rings and staggered -rings [Gilson et al, J. Chem. Soc. (1946) p. 456; Kakinoki et al, cta Crystal., Vol. 10, Pt 12, 829 (1957)]. The curve for the turbo-tratic layer model departs widely from the experimental results t interatomic distances greater than 3 A. V.E.Cosslett

539.23

### 4695 A SPECIAL CASE OF DECOMPOSITION OF CUPROUS OXIDE IN VACUUM.

R.Seidl and V.Střelka.

zech. J. Phys., Vol. 9, No. 6, 757 (1959). In German.

It was found that, while pure $Cu_2O$ films can be heated in vacuum o over 500°C without undergoing decomposition, a 1000 Å thick $Cu_2O$ layer with a superposed Cu layer 100 A thick undergoes de-omposition in vacuum when the temperature reaches 280°C. A entative explanation is given. F.Lachman

539.23

### 4696 CONDENSATION ENERGIES FOR METALS ON GLASS AND OTHER SUBSTRATES.

P.Benjamin and C.Weaver.

Proc. Roy. Soc. A, Vol. 252, 418-30 (Sept. 29, 1959).

Earlier work on condensation phenomena is briefly reviewed, and existing measurements of condensation energies are summarized. Measurements of condensation energies have been made for aluminium, silver and cadmium on glass and for aluminium and silver on single-crystal cleavage surfaces of sodium chloride and potassium bromide. Adhesive energies or binding energies between film and substrate have been calculated in each case. Association energies for nucleation are obtained by difference and shown to be consistent. Results for cadmium show good agreement with earlier work, but results for aluminium do not agree with the earlier results of Rhodin (1949) who measured the condensation energies for aluminium on various substrates, obtaining values which suggest chemisorption. These results appear to be too high and a possible explanation is given. It is concluded that the adhesive energy is due to physical adsorption and can be explained in terms of van der Waals forces only.

539.23

### 4697 STRUCTURE OF EVAPORATED FILMS OF IRON AND THEIR OXIDES (INVESTIGATED BY ELECTRON DIFFRACTION).

O.Haase.

Z. Naturforsch, Vol. 14a, No. 10, 920-2 (Oct., 1959). In German.

Very thin films of iron (about 10 A thick), deposited by evaporation, have the normal body-centred structure when the substrate is at room temperature and if it is of glass, rock salt, or copper. Deposition at high temperature (350-450°C) also gives the body-centred form when the substrate is LiF or NaCl, but when it is copper the face-centred structure of iron is obtained, which normally is stable only above 900°C. The reason is that copper has the same lattice structure, and the same lattice constant within 25%, as face-centred iron. The presence of face-centred iron was proved by oxidizing the film and obtaining the electron diffraction pattern of the oxide. The formation of the oxide lattice on body-centred and on face-centred iron is discussed in terms of the relative size of the oxygen ion and of gaps in the iron lattice. V.E.Cosslett

539.23 : 621.319.45

### 4698 ELECTRON CONDUCTIVITY AND GRAIN STRUCTURE OF ANODICALLY FORMED ALUMINIUM OXIDE FILMS.

S.Raether.

Z. angew. Phys., Vol. 11, No. 12, 456-60 (Dec., 1959). In German.

The films considered are of the insulating type formed in boric acid. A comparison between weight increase of the aluminium foil and charge transported during forming shows that for final voltages above 200, there is an appreciable contribution from an electronic current through the oxide. A change in film structure at the same voltage is deduced from measurements of mechanical stress in the film and from the effect on leakage current of dissolving some of the oxide in chrome-phosphoric acid. K.W.Plessner

539.23 : 621.357.5

### 4699 THE ADHESION OF ELECTRODEPOSITED NICKEL TO CHROMIUM AT ELEVATED TEMPERATURES.

W.E.Reid, Jr and F.Ogburn.

J. Electrochem. Soc., Vol. 107, No. 2, 91-3 (Feb., 1960).

The use of a composite coating of electrodeposited nickel and chromium to protect molybdenum from oxidation at elevated temperatures has certain practical limitations. Examination of the composite coating showed that the problems of blister formation, weakening of the bond between nickel and chromium, and edge separation were interrelated. Blister formation was eliminated and edge separation reduced slightly by an improved treatment of the chromium surface prior to nickel plating. The weakening of the bond between nickel and chromium appears to be inherent in the coating system.

## X-ray and Electron Microscope Examination

539.27

### 4700 ELECTRON FIELD EMISSION MICROSCOPY OF CRYSTALS OF ORDER—DISORDER ALLOYS.

A.P.Komar, V.P.Savchenko and V.H.Shrednik.

Dokl. Akad. Nauk SSSR, Vol. 129, No. 3, 540-3 (Nov. 21, 1959). In Russian.

The authors point out that electron field emission microscopes have usually been limited to the study of high melting point metals such as tungsten, since low melting point materials cannot withstand the initial cleaning of the tip by field desorption or by thermal heating. The authors overcome this difficulty by sparking the tip under vacuum. This raises protuberances at which field emission can occur. Alloys investigated include $AuCu_3$, $PtCu_3$. The method was also used to demonstrate the considerable mobility of manganese in $Ni_3Mn$. T.Mulvey

539.27

4701 **TRANSMISSION SPECIMEN HOLDER FOR ELECTRON DIFFRACTION.** R.I.Garrod and R.K.Hart.

J. sci. Instrum., Vol. 36, No. 1, 44-5 (Jan., 1959).

A specimen stage for electron diffraction and electron shadow microscopy has been constructed, to enable a holder containing two transmission specimens to be inserted into, or withdrawn from, the specimen chamber without breaking the vacuum in the system. The time required to change specimens is less than one minute. Controls are provided to give specimens two independent translations in a plane normal to the electron beam and a rotation about the axis of the holder.

539.27 : 537.533

PREPARATION OF THE SURFACE OF A THERMIONIC CATHODE PRIOR TO EXAMINATION BY ELECTRON DIFFRACTION. See Abstr. 3788

539.27

4702 **INTEGRATING EXPOSURE METER FOR ELECTRON MICROSCOPY.** J.Cartwright and A.E.Bishop.

J. sci. Instrum., Vol. 36, No. 7, 303-4 (July, 1959).

The integrating meter described depends upon the scattered X-ray emission from the plate being exposed, and ensures correct exposures under diverse conditions. The instrument has proved stable and reliable in operation.

539.27

4703 **Cr-PRESHADOWED CARBON REPLICA BY SINGLE STAGE PROCESS.** K.Izui and T.Fujiwara.

J. Sci. Hiroshima Univ. A, Vol. 22, No. 3, 247-50 (Dec., 1958).

For the electron microscope study of metal surface a replica process is described of Cr-preshadowing directly on to the metal surface then depositing a carbon film on this Cr-preshadowed surface, and then removing from the metal. By means of this method fine slip lines 50 A apart on aluminium single crystal plates could be detected, which is not possible using the ordinary methylmethacrylate Cr-preshadowed carbon replica. The reason why this replica can copy more details than the ordinary one is discussed.

539.2

4704 **IMAGING OF SIDES AND SHARP EDGES.** K.J.Schulze.

Optik, Vol. 16, No. 12, 725-31 (Dec., 1959). In German.

The impression procedures employed in electron microscopy are often inadequate when dealing with sharp corners and edges, the surfaces of which form an acute angle. Such specimens are ver easily damaged. A way is given to prepare the immediate vicinity of sharp edges for precise electron microscopic examination. The objects are pressed into previously hardened matrix material and then prepared according to the usual procedure.

539.2

4705 **ON THE DECOMPOSITION OF INORGANIC CRYSTALS IN THE ELECTRON MICROSCOPE.** L.Reimer.

Z. Naturforsch., Vol. 14a, No. 8, 759-60 (Aug., 1959). In German.

The minimum illuminating current density ($i_c$) required to init ate evaporation has been experimentally determined in the electron microscope for a variety of metals and inorganic crystals. Their dimensions were between 0.5 μ and 1 μ, and the melting points ($T_s$) ranged from 540°K (for Bi) to 1630°K (for $CaF_2$). The value of $i_c$ was found to be proportional to $T_s^4$, confirming that for electron-opaque crystals the energy dissipation is essentially by radiation only. For $T_s = 1000°K$, $i_c = 5 \times 10^{-2}$ A cm$^{-2}$. Scatter of the experimental points may be due to departures either from the fourth-power law or from black-body emission. From the results for meta for which the value of the emissivity is better known, it is deduced that the mean energy loss per electron is only 5-8 eV. This very small value, in comparison with the beam energy of 60 keV, is explained by the high proportion of electrons which are elastically scattered out of the crystals. V.E.Cosslet

539.27 : 537.53

EVIDENCE OF FLUCTUATING CHARGES IN THIN COLLODIO FILMS DURING ELECTRON IRRADIATION. See Abstr. 3785

# PHYSICAL CHEMISTRY

541

4706 **HETEROGENEOUS MULTICOMPONENT SYSTEMS WITH A CONCENTRATION MATRIX OF NON-MAXIMUM RANK.** L.S.Palatnik and A.I.Landau.

Z. Phys. Chem. (Leipzig), Vol. 213, No. 1-2, 89-110 (1960). In German.

In previous work the authors have discussed the topology of phase-equilibrium diagrams in a very general way. Such topics as generalized "lever" rules and the dimensionality and qualitative nature of projected diagrams are apparently dealt with. This work has been restricted to the commonest situations in which the matrix $x_{ij}$ giving the concentration of the i th of n components in the j th of r phases has its maximum rank: $R = R_{max} = \max(r,n)$. In the present paper the authors generalize their arguments to deal with systems for which $R = R_{max} - \sigma$ where $0 \leq \sigma \leq R_{max}$. Such systems include, with $\sigma = 1$, those often called "indifferent" or "azeotropic". The Gibbs rule, $r \leq n + 2$, is now replaced by $n \leq \sigma + R_{max} \leq n + 2$; generalizations are found for the concepts of "invariant" and "monovariant" systems and the lever rule is extended. R.O.Davies

## THERMOCHEMISTRY . REACTIONS

541.12

4707 **NEGATIVE ION—MOLECULE REACTIONS.** A.Henglein and G.A.Muccini.

J. chem. Phys., Vol. 31, No. 5, 1426-7 (Nov., 1959).

A number of reaction systems in which negative ions are formed were studied on a mass spectrometer. The results are interpreted in terms of the relative electron affinities of the reactants and show that certain of these reactions can occur at very low activation energy. G.I.W.Llewely

541.1

4708 **PERTURBATION OF MOLECULAR DISTRIBUTION FUNCTIONS BY CHEMICAL REACTION.** B.H.Mahan.

J. chem. Phys., Vol. 32, No. 2, 362-4 (Feb., 1960).

A collision cross-section for radical combination reactions is derived which indicates that translationally hot free radicals combine faster than the average thermal radicals. The cross-section is used to calculate the disturbance of the equilibrium distribution of velocities by radical combination reactions. It is concluded that the equilibrium assumption of chemical kinetics is justified for photochemical systems where the radical concentrations are low, but may be violated in systems where free radical concentrations approach 0.1 mole fraction.

541.12 : 548.7 : 539.

4709 **THE CATALYTIC ACTIVITY OF SILVER CRYSTALS O VARIOUS ORIENTATIONS AFTER BOMBARDMENT WITH POSITIVE IONS.** H.M.C.Sosnovsky.

J. Phys. Chem. Solids, Vol. 10, No. 4, 304-10 (Aug., 1959).

Single crystals of silver with surfaces oriented parallel to (111 (110) and (100) have been bombarded with positive argon ions at voltages between 14 and 4000 V. The catalytic decomposition of formic acid has been used as a test reaction in the temperature range 150-250°C. The parameters log A and E found from Arrhenius plots change appreciably with bombarding ion energy and for each ion energy are different for three orientations. It is concluded that the reaction occurs at sites where dislocation lines intersect the surfac and that a compensating effect occurs which is associated with interaction between dislocations when their density is high.

541.12

4710 REACTION OF ACETYLENE WITH METHYL RADICALS. C.M.Drew and A.S.Gordon.
hem. Phys., Vol. 31, No. 5, 1417-18 (Nov., 1959).

Methyl free radicals were photochemically generated in the sence of acetylene between 200° and 500°C. Benzene was the jor reaction product, and propylene the second most important duct. The reaction mechanism is discussed. W.Good

541.12

4711 UNIMOLECULAR DECOMPOSITION OF CHEMICALLY ACTIVATED ETHYL-$d_2$ RADICALS.
S.Rabinovitch, D.H.Dills, W.H.McLain and J.H.Current.
chem. Phys., Vol. 32, No. 2, 493-8 (Feb., 1960).

Addition of H atoms to trans-ethylene-$d_2$ produces chemically ivated ethyl-$d_2$ radicals. This choice of the reactant ethylene rmits all subsequent secondary processes of the hot ethyl radicals be counted. The system was studied between −78° and 160°C, and most detail at room temperature, as a function of ethylene presre. Experimental details are similar to those given in previous rk on butyl. The relative energy spread of the formed ethyl radis is here effectively greater than that observed for butyl radical ce the thermal spread is not superimposed upon a minimum cess above the critical energy, as was the case for butyl. Neverless, relative to high-temperature thermal decompositions, the oduct ethyl radicals are comparatively monoenergetic, especially the lowest temperature. The observed rate constant for decompoion $k_a$ was evaluated from the amounts of stabilization versus demposition by C−H rupture. The decomposition rate is compared th theoretical expressions. An isotope effect appears to exist for nsfer of H and D in the disproportionation of ethyl-$d_2$ radicals 25°.

541.12

4712 ISOTOPE EFFECTS IN THE CHROMIC ACID OXIDATION OF BENZYL-α-t ALCOHOL.
M.Hodnett and L.Kaplan.
chem. Phys., Vol. 32, No. 1, 312-13 (Jan., 1960).

A study of the isotope effect in the oxidation of benzyl-α-t cohol, $C_6H_5$.CHT.OH, indicates that the tritiated alcohol is idized more slowly than the normal compound, the ratio of the te constants at 37.5°C being 0.69. W.J.Orville-Thomas

## ELECTROCHEMISTRY

541.13

4713 KINETICS OF THE DEPOSITION AND DISSOLUTION OF SILVER. A.R.Despic and J.O'M. Bockris.
chem. Phys., Vol. 32, No. 2, 389-402 (Feb., 1960).

Galvanostatic measurements, made on spherical silver electrodes highly purified acid solutions of silver perchlorate at current ensities up to 10 amp $cm^{-2}$, gave overpotential as a function of time nd Faradaic current density at constant total current. Variables ere total current density, concentration of silver ions and state of e electrode surface. The theory of the surface diffusion kinetics as developed to encompass high current density regions and the urface adion concentration ($c_{ad}{}^0$) evaluated. A theoretical analysis the steady state of surface diffusion control of the metal-ion xchange reaction shows that the current is distributed nonuniformly etween growing sites, with constant potential over the electrode surce. An equation previously developed by Rojter, Juza and olujan has been modified and shown to be applicable to galvanotatic transients when the transfer reaction is rate controlling. The ymmetry factor β, of electrode kinetics, is shown to be potential ependent, and, in systems of sufficiently high $i_0$ values, to tend to ero at high overpotential. This results in a limiting current ensity for a transfer controlled process. The tendency towards such current was observed and shown to be quantitatively consistent with ne discussion of β.

541.13

4714 DIFFUSION-EXCHANGE OF EXCHANGE IONS AND NONEXCHANGE ELECTROLYTE IN ION-EXCHANGE MEMBRANE SYSTEMS. M.A.Peterson and H.P.Gregor.
J. Electrochem. Soc., Vol. 106, No. 12, 1051-61 (Dec., 1959).

The following parameters of cation- and anion-permeable membrane systems were measured: water content; ohmic resistance; exchange capacity; diffusible electrolyte content; concentration potential; rate of exchange-diffusion of electrolytes; rate of diffusion of nonelectrolytes; effect of rate of stirring on diffusive flux. From these were calculated: the thickness of the unstirred film, which varied from 1 to 30 microns; the diffusion coefficient of potassium ion in a sulfonic acid cation-permeable membrane, which was found to vary from $1.09 \times 10^{-7}$ $cm^2$ $sec^{-1}$ to twice that value as the ambient solution concentration was changed from 0.001 to 0.1M; the diffusion coefficient of the chloride ion which remained at about $3 \times 10^{-7}$; the diffusion coefficients of nonelectrolytes. A theoretical treatment showed that diffusion coefficients and other parameters could be estimated from a consideration of pore diameters, a tortuosity factor, and water contents.

541.13

4715 CAPILLARY pH ELECTRODE. R.H.Wilkinson.
J. sci. Instrum., Vol. 36, No. 10, 424-5 (Oct., 1959).

A robust glass electrode and stable liquid junction is described. The precision for venous blood is ± 0.0015 pH unit over the range 20 to 40°C under strictly anaerobic conditions.

541.13

4716 THE MANGANESE DIOXIDE ELECTRODE. W.C.Vosburgh.
J. Electrochem. Soc., Vol. 106, No. 9, 839-45 (Sept., 1959).

This review brings together some of the more recent contributions to the structure and properties of $MnO_2$ and the discharge mechanism of the $MnO_2$ electrode. The structural forms of $MnO_2$ are discussed fully. Recent information on the properties such as changes on heating, surface areas, ion exchange and isotope exchange, magnetic susceptibility, conductivity and activity of the $MnO_2$ are covered. The lower oxides of manganese are also dealt with. The electrode discharge mechanisms are discussed in the light of new experimental data and different theories compared. More research is needed to reconcile the different theories that have been proposed. 64 references. W.A.Walker

541.13

4717 A COMPARISON OF THE RESULTS OF TWO METHODS OF MEASURING THE ISOTOPE EFFECT BY ELECTROMIGRATION IN MOLTEN NITRATES. L.Lundén.
Z. Naturforsch., Vol. 14a, No. 9, 801-5 (Sept., 1959). In German.

The electromigration isotope effect has been measured using packed tubes, and by electrophoresis in asbestos paper; by this means the relative mobilities of the anions and the cations have been obtained. Reasons are discussed for the apparent differences in the isotope effect when measured by the two methods. H.C.Cole

541.13 : 539.18

4718 THE ELECTROMIGRATION OF RADIOACTIVE IONS IN FUSED SALTS. APPLICATION TO THE SEPARATION OF ISOTOPES. H.J.Arnikar.
Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 11-12, 1291-1340 (Nov.-Dec., 1959). In French.

This is a detailed review of the subject in which the work of the author and his colleagues is discussed, in relation to that of other workers, under four main headings, namely: (i) electrochemical properties of molten salts: (ii) chromatographic separation on paper; (iii) electromigration of different ions in fused salts: (iv) separation of isotopes by electromigration in fused salts. In particular the migration of mono- and multivalent ions in molten $NaNO_3$ is discussed, also the influence of temperature, the composition of the migration medium, the mobility and dimensions of the ions etc. The experimental method is also described in detail. H.C.Cole

541.13 : 539.17

4719 AMP —EFFECTIVE ION EXCHANGER FOR TREATING FISSION WASTE. J.van R.Smit, W.Robb and J.J.Jacobs.
Nucleonics, Vol. 17, No. 9, 116, 118, 120-3 (Sept., 1959).

Ammonium molybdophosphate (AMP) mixed with asbestos fibre has been tested with both neutral and acidic fission product solutions, and suitable elutriants investigated for the separation of Sr, rare earths and Cs. Radiation tests on small samples have indicated that AMP ion-exchangers are resistant to radiation damage. R.D.Smith

541.13

4720 ANOMALOUS PROTON CONDUCTANCE AND THE MECHANISM OF DIPOLE ROTATION IN WATER AND ICE. B.E.Conway.
Z. Naturforsch., Vol. 149, No. 9, 841-2 (Sept., 1959).

The previous conclusions of the author et al. (Abstr. 4062 of 1956; 8504 of 1958) regarding the rate-determining step in proton mobility in relation to dipole rotation in water and in ice remain unchanged after consideration is given to some points raised by Eigen and De Maeyer [The Structure of Electrolytic Solutions. New York: John Wiley (1959) p.64] concerning the mechanism of proton conductance in aqueous solutions. W.Good

541.13

4721 ON THE THEORY OF PROTON CONDUCTANCE IN WATER AND ICE. B.E.Conway and J.O'M.Bockris.
J. chem. Phys., Vol. 31, No. 4, 1133-4 (Oct., 1959).

The tunnelling probability, the rate-determining step, and the energy barrier, as factors in the mechanism of proton mobility in water and ice, are reconsidered. No reason can be found for altering the conclusions already arrived at by the authors (Abstr. 5665 of 1959). W.Good

541.13

4722 COMMENT ON THE LETTER OF B.E.CONWAY AND J.O'M.BOCKRIS. M.Eigen and L.de Maeyer.
J. chem. Phys., Vol. 31, No. 4, 1134 (Oct., 1959).

See preceding abstract. It is claimed that no experimental evidence exists for the conclusion that H-bonded $H_2O$ molecules in the liquid phase have the same thermal orientation relaxation time as in a complete ice lattice, or for the validity of the numerical value of the potential barrier for proton transfer from $H_3O^+$ to $H_2O$. W.Good

541.13

4723 INITIAL THERMOELECTRIC POWERS OF THE NON-ISOTHERMAL CALOMEL CELL.
W.A.Hawksworth and C.J.G.Raw.
J. chem. Phys., Vol. 31, No. 5, 1421-2 (Nov., 1959).

Some selected experimental results for $\Delta(dE/dT)$ are compared with theoretically calculated values. When the temperature interval $\Delta T$ is less than 10 deg. the comparison is satisfactory and it should be possible to apply the theory to the determination of Soret coefficients and heats of transfer. An outline of the experimental procedure used is given. W.Good

541.13 : 539.2 : 537.311

4724 CONTINUOUS DEIONIZED WATER WASHING SYSTEM FOR SEMICONDUCTOR DEVICES.
V.J.Jennings and R.D.Knight.
J. sci. Instrum., Vol. 36, No. 10, 432-4 (Oct., 1959).

Designed for use on a batch production basis, the apparatus provides for the recirculating water to pass through an ion exchange resin after washing the devices. Two conductivity cells, one on either side of the washing point, measure the specific resistivity of the circulating water; this is $20 \times 10^6$ ohm cm at 18°C in water about to pass over the devices, i.e. deionized water. The apparatus is constructed mainly of polythene and P.V.C. to avoid contamination of the water.

## PHOTOCHEMISTRY
## RADIATION CHEMISTRY

541.14

4725 PRIMARY PROCESSES IN THE PHOTOCHEMISTRY OF EOSIN. L.I.Grossweiner and E.F.Zwicker.
J. chem. Phys., Vol. 31, No. 4, 1141-2 (Oct., 1959).

Describes flash photolysis experiments which show that in the eosin–phenol system there is a reactive state of lifetime about $10^{-4}$ to $10^{-5}$ sec duration. Spectral evidence suggests that the primary photochemical act is collisional electron transfer from phenol to a metastable state of eosin. W.Good

541.14

4726 ON THE PHOTOSENSITIVITY OF MINUTE SINGLE CRYSTALS OF $BaTiO_3$. H.Arend.
Czech. J. Phys., Vol. 9, No. 1, 124 (1959).

After exposing small crystals of $BaTiO_3$ to daylight for 24 hour the crystals darkened, indicating that a photochemical reaction occurred. J.Frank

541.1

4727 NITROGEN CHAINED COMPOUNDS AS INTERMEDIAT IN THE PHOTOLYSIS OF SOLID $HN_3$. H.A.Papazian.
J. chem. Phys., Vol. 32, No. 2, 456-60 (Feb., 1960).

The ultraviolet and visible absorption spectrum of irradiated solid $HN_3$ was studied. Gas evolution during warmup of irradiated samples was analyzed. It is proposed that photolysis in the solid yields NH radicals which react with the matrix to form the nitroge chained compounds diminohydrazine (H—N=N—N=N—H), triazene ($H_2$—N—N=N—H), and the radical H—N=N. The latter is responsib for the blue colour and paramagnetism of the solid. Multichained nitrogen compounds are known only as organic derivatives. Here they are formed and stabilized at low temperatures. On warmup of the blue solid, these compounds undergo decomposition yielding the products found from the blue solid.

541.15

4728 NEW PROOFS OF THE PRECIPITATION OF METALLIC LITHIUM IN THE SALTS OF LITHIUM IRRADIATED WITH THERMAL NEUTRONS.
M.Lambert, P.Berge, C.Mazières and A.Guinier.
C.R. Acad. Sci. (Paris), Vol. 249, No. 20, 2054-6 (Nov. 16, 1959).
In French.

The precipitation of metallic lithium in neutron-irradiated LiF and LiH has now been confirmed by differential thermal analysis, a well as by X-ray examination. B.T.M.Will

541.

4729 PECULIARITIES OF OZONE FORMATION IN ELECTRON IRRADIATION OF NITROGEN–OXYGEN MIXTURES. J.E.Douglas, L.C.Bratt and E.M.Kinderman.
J. chem. Phys., Vol. 31, No. 5, 1416 (Nov., 1959).

Electrons of 600-700 keV average energy at a dose-rate of $14 \times 10^6$ rep/min were used to irradiate $N_2$—$O_2$ gas mixtures axially in a cylinder 12 in. long, 3 in. diameter. The gases were a atmospheric pressure and continuously passed through the reactio vessel with a residence time of 3 min. Ozone and nitric oxide production were followed photometrically. Production of ozone during, and decay after, irradiation depended on the material of the reaction vessel. Aluminium, anodized aluminium and pyrex were used. M.Ebe

541.

4730 HYDROGEN FORMATION IN THE RADIATION CHEMISTRY OF WATER. H.A.Mahlman.
J. chem. Phys., Vol. 32, No. 2, 601-3 (Feb., 1960).

The molecular hydrogen yields in concentrated aqueous sodiu nitrate solutions by cobalt-60 gamma-ray irradiation were observe and correlated with the molecular hydrogen yields observed in dilu solutions. The $G(H_2)$ plotted as the cube root of the $NaNO_3$ activity exhibits a sharp break indicative of a change in the mechanism of formation. The predominant process, designated $E_1$, is readily affected by a scavenging solute. A process of lesser magnitude, designated $E_2$, is less susceptible to solute scavenging. The shar break is interpreted as the cessation of the $E_1$ process. The $G(H_2)$ observed in the $NaNO_3$ solutions at 298° K is correlated with the $G(H_2)$ observed in ice at 77° K. Of paramount importance is the observation that the hydrogen formed by the $E_1$ process may be eli nated by irradiation of aqueous nitrate solutions at 77° K. The $G(D_2)$ data observed in comparable $D_2O$—$NaNO_3$ solutions also exhi the same mechanisms of formation. The isotope effect on the formation of $D_2$ in $D_2O$ is in qualitative agreement with two initial distributions of the H atoms.

541.1

4731 SOME OBSERVATIONS ON BIPHENYL RADIOLYSIS. K.L.Hall and F.A.Elder.
J. chem. Phys., Vol. 31, No. 5, 1420-1 (Nov., 1959).

Recrystallized, distilled and gas-free biphenyl was irradiated at 74° C or 82° C inside a 10 kilocurie $Co^{60}$ source to $10^{21}$ eV/g. Mass spectrometric analysis gave G values for the following products: hydrogen, acetylene, diacetylene, benzene, toluene, dihydrobiphenyl, tetrahydrobiphenyl, hexahydrobiphenyl. Relative yields for terphenyl, quaterphenyl, quinquaphenyl and hexaphenyl were also estimated. M.Eber

541.15

4732 **EFFECTS OF GASES ON IRRADIATED POLYVINYL CHLORIDE AS STUDIED BY ELECTRON SPIN SONANCE.** Z.Kuri, H.Ueda and S.Shida.
chem. Phys., Vol. 32, No. 2, 371-4 (Feb., 1960).

The radicals produced by gamma irradiation of polyvinyl chlor- powder in various gases and in vacuum were observed by elec- n spin resonance. Different patterns were observed for the ir- diation in vacuum, air, and sulphur dioxide. No electron spin sonance absorption was obtained by the irradiation in nitrogen ide, halogens, and hydrogen sulphide. The recombination reaction locity of the radical produced in vacuum was measured at dif- rent temperatures; the activation energy was found to be kcal/mole.

541.15

4733 **ISOMERIC EFFECTS IN FRAGMENTATION BY BETA DECAY : MONOTRITIATED PROPANES AND LUENES.** S.Wexler, G.R.Anderson and L.A.Singer.
chem. Phys., Vol. 32, No. 2, 417-27 (Feb., 1960).

The spectra of positively charged fragments from beta decay of tium in primary and secondary monotritiated propane and in o-, , p- and α-monotritiated toluene were determined by mass spec- metric techniques. Although the number of products from de- mposition of each molecule is quite large, the mass patterns from two propanes are fairly similar while the four mass spectra om the isomeric tritiated toluenes are very nearly the same. These sults suggest that the influence of the location of the radioactive om in the molecule on the fragmentation following beta decay is en obscured by secondary processes, such as radiationless tran- ions, H-atom migration, and other rearrangements of the excited lecular ion before breakup. However, there are significant diff- ences within the two groups of mass spectra. Some of the differ- ces in the propane patterns are consistent with the greater stabil- of the secondary propyl structure as compared to that of the imary isomer. Energetically plausible decomposition schemes the tritiated propanes are proposed. The distributions of exci- tion energies made available to the daughter molecular ions $_3H_7He^3)^+$ in the beta transformation of $H^3$ to $He^3$ are estimated.

541.15

4734 **ION–MOLECULE CHARGE TRANSFER REACTIONS IN THE ALPHA RADIOLYSIS OF VARIOUS YDROCARBONS IN A MASS SPECTROMETER.**
.S.Rudolph and C.E.Melton.
chem. Phys., Vol. 32, No. 2, 588-9 (Feb., 1960).

The new alpha-particle mass spectrometer proves to be a owerful tool for the study of charge transfer between gaseous ions nd molecules. Energetically possible charge-transfer reactions ave been differentiated into probable and improbable reactions by mploying binary mixtures of hydrocarbon gases in this instrument. The alpha particle induced charge-transfer reaction, $C_2H_2^+ + C_6H_6 \rightarrow C_2H_2 + C_6H_6^+$, is shown to be very efficient. In contrast, the charge-transfer reaction, $C_2H_2^+ + C_2H_4 \rightarrow C_2H_2 + C_2H_4^+$, s shown to be inefficient. This inefficiency is discussed in terms of he competing chemical reaction, $C_2H_2^+ + C_2H_4 \rightarrow C_3H_3^+ + CH_3$.

541.15

4735 **DECOMPOSITION OF THE OXALATES OF PLUTONIUM UNDER THE ACTION OF ITS OWN α-RADIATION.**
V.V.Fomin, R.E.Kartushova and T.I.Rudenko.
J. nuclear Energy, Vol. 4, No. 2, 247-52 (Feb., 1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 3, 117 (1956).

The process of decomposition of the oxalates of tri-, tetra-, and hexavalent plutonium on standing in air and in vacuum at room temperature and at −80° has been investigated, both in the light and in the dark. It has been established that the decomposition occurs under the action of plutonium α-radiation, but in the case of tetra- and hexavalent plutonium oxalates the carbon monoxide formed acts as a reducer and causes the transistion of the tetravalent plutonium to the trivalent and of the hexavalent to the tetravalent. In these two cases the oxalates are transformed into carbonates and, apparently, in part into oxides or into oxyoxalate-carbonate mixtures.

# DISPERSIONS . COLLOIDS
# ADSORPTION

541.18

4736 **THE OVERHAUSER AND DOUBLE EFFECTS IN LIQUIDS ADSORBED ON CARBON.**
M.Jacubowicz and J.Uebersfeld.
C.R. Acad. Sci. (Paris), Vol. 249, No. 25, 2743-5 (Dec. 21, 1959).
In French.

A study of double resonance effects using benzene adsorbed on carbon produced by charring sugars at various temperatures. For charring temperatures above 600°C an Overhauser effect is observed and below 600°C the "double effect", i.e. resonances at $\nu_e \pm \nu_n$. For carbon prepared at 600°C the effect of oxygen is unusual.

J.G.Powles

541.18 : 534.8

4737 **EFFECT OF SOUND INTENSITY ON DISPERSION AND COAGULATION IN ULTRASONIC EMULSIFICATION.**
R.S.Krishnan, V.S.Venkatasubramanian and E.S.Rajagopal.
Brit. J. appl. Phys., Vol. 10, No. 6, 250-2 (June, 1959).

The method of following the rate of emulsification is used. After a certain threshold of intensity, below which no cavitation occurs, the dispersion increases with the sound intensity. The coagulation also increases with the sound energy, but with a residual coagulation even in the absence of the sound field. The nucleation phenomenon is also studied. All the results agree with the general theoretical considerations.

541.18

4738 **MOTION OF GAS BUBBLES IN A LIQUID UNDER THE INFLUENCE OF BJERKNES FORCES ARISING IN AN ACOUSTIC FIELD.** V.F.Kazantsev.
Dokl. Akad. Nauk SSSR, Vol. 129, No. 1, 64-7 (Nov. 1, 1959).
In Russian.

The hypothesis is examined that coagulation of gas bubbles suspended in a liquid in an ultrasonic field occurs as a result of forces between two oscillating bodies (Bjerknes forces). The Bjerknes forces are expressed in terms of the parameters of the bubbles and the sound field. An experimental arrangement, using rapid cinematography, is described for following the coagulation process, and frames from the films are reproduced. It is found that coagulation starts only after switching on the sound field. Measurements of size of bubbles as a function of time support the theoretical equations.

R.F.S.Hearmon

541.18

4739 **SEDIMENTATION RATES, FLUIDIZATION AND FLOW THROUGH POROUS MEDIA.** C.C.Harris.
Nature (London) Vol. 184, 716 (Aug. 29, 1959).

Several equations describing sedimentation and fluidization phenomena are reviewed. Suggestions which might account for differences are advanced.

E.G.Knowles

541.18

4740 **SEDIMENTATION AND EFFECTIVE VISCOSITY.** G.J.Kynch.
Nature (London), Vol. 184, 1311 (Oct. 24, 1959).

Calculation shows that there is a theoretical relationship $\mu u = \mu_0 V(1 - c)$ connecting the sedimentation velocity u of particles falling through a liquid of viscosity $\mu_0$ and the effective viscosity $\mu$ of a suspension of similar particles having the same density as the fluid, the small concentration by volume being c in each case. V is the velocity of fall of an isolated particle in the liquid as given by Stokes' formula.

J.G.Oldroyd

541.18

4741 **INVESTIGATIONS ON SUSPENDED PARTICLES IN A TEMPERATURE GRADIENT.** K.H.Schmitt.
Z. Naturforsch., Vol. 14a, No. 10, 870-81 (Oct., 1959). In German.

To avoid convection currents the upper condenser plate in a kind of Millikan experiment was maintained at the higher temperature. Droplets of various silicone oils and kerosine were examined in argon, nitrogen, carbon dioxide, and hydrogen. Stokes' law applies for large particles, whereas for particles of less than .1μ radius a correction factor must be applied. The experimentally determined constants for this factor were about 10% larger than the theoretical values, when no temperature gradient had been applied. $H_2$ has the greatest proportion of elastically reflected molecules. With a constant temperature gradient of 49.4 deg C/cm a temperature difference on the suspended particles which obeyed the condition $r/l > 5$ was verified in a model experiment on macroscopic spheres in a vacuum. The velocity of the particles was found to be independent of their radius in the ranges of small and of comparatively large particles. For large particles the heat transport through the particle and through the gas were also of importance.

R.Schnurmann

541.18

4742 IMPACTION SAMPLER FOR SIZE GRADING AIR-BORNE BACTERIA-CARRYING PARTICLES.
O.M.Lidwell.
J. sci. Instrum., Vol. 36, No. 1, 3-8 (Jan., 1959).

A sampler for air-borne bacteria is described which separates the sample into four fractions each collected on to the agar surface of a Petri dish. The sampling rate is approximately 20 $ft^3$/min, the size limits to the fractions are, above 18 $\mu$ diameter, between 10 and 18 $\mu$, between 10 and 4 $\mu$ and below 4 $\mu$. There is considerable overlap between the fractions but reasonable estimates of the median particle diameter and the dispersion of particle size within the sample can be made so long as these fall within the working limits of the instrument.

541.18

4743 MEASUREMENT OF ASBESTOS DUST CONCENTRATIONS WITH THE LONG-RUNNING THERMAL PRECIPITATOR. C.G.Addingley and R.Gaze.
Nature (London), Vol. 184, 715-16 (Aug. 29, 1959).

Results of a series of measurements in two factories show that the calculated number of particles per $cm^3$ of air decreases with increase of running time of the precipitator. A brief discussion of other cases is included. E.G.Knowles

541.18 : 539.1.07

ELECTRON MICROSCOPE STUDY OF AEROSOLS USING NUCLEAR TRACK EMULSIONS. See Abstr. 3904

541.18 : 539.213

4744 CONTRIBUTION TO THE STUDY OF SOME PROPERTIES OF VITREOUS SILICA IN CONTACT WITH AQUEOUS SOLUTIONS: BEHAVIOUR OF SUSPENSIONS, ELECTROKINETIC MOBILITIES. M.Baruch-Weill.
Ann. Phys. (Paris), Ser. 13, Vol. 4, No. 9-10, 1159-86 (Sept.-Oct., 1959). In French.

The zone formation and distribution during the sedimentation of very finely ground vitreous silica in water was investigated. No interaction between the suspended particles was found. With HCl ($10^{-5}$ to $10^{-3}$M) the electro-osmotic and electrophoretic mobilities differed by a factor of 3. The electrophoretic mobility in dilute KCl was independent of concentration. With bromolauryl methylammonium the ratio between the electro-osmotic and electrophoretic mobilities was constant and very large. The different behaviour of HCl and KCl was apparent with regard to both the electrophoretic mobility and the formation of zones of sedimentation.

R.Schnurmann

541.18 : 535.43

EFFECT OF ADSORBED WATER ON THE OPTICAL TRANSMISSION PROPERTIES OF ISOTROPIC POWDERS. See Abstr. 3650

541.18

4745 CHANGE OF ADSORPTIVE PROPERTIES OF SILICA GEL, DUE TO GAMMA RADIATION.
S.V.Starodubtsev, Sh.A.Ablyaev and S.E.Ermatov.
Dokl. Akad. Nauk SSSR, Vol. 129, No. 1, 72-3 (Nov. 1, 1959). In Russian.

It was found that the Soviet KSK silica gels, when subjected to prolonged and careful heat treatment followed by irradiation with $\gamma$-rays (dose range 1.5-3.5 × $10^5$ r/hr, total dose 1.5-2 × $10^6$ r), adsorbed greater quantities of gases (A, $N_2$, $H_2$, $H_2S$, $CO_2$, CO, $NH_3$, $C_2H_4$), the increase being very different for different gases. When heated (annealed) at 100° C the silica gel regained completely the initial adsorptive capacity. F.Lachman

541.18

4746 SOME ASPECTS OF THE RHEOLOGY OF MILK GEL.
C.S.Landau.
Brit. J. appl. Phys., Vol. 10, No. 11, 476-81 (Nov., 1959).

Observations of the flow of milk gel have been analysed and shown to be in general agreement with Graham's theory of deformation. Individual creep curves are satisfactorily described by the sum of powers of time $t^{1/3}$, $t^1$ and $t^3$. The effect of stress on the creep of gels of various ages can be described by the sum of power terms with simple exponents. At small values of time the strain recovere after removal of stress is proportional to the one-third power of time. There is general agreement between the predicted hysteresis loops and those observed in repeated loading tests.

541.18

4747 FOAM FORMATION AND FOAM STABILITY.
R.R.Lauwers and R.Ruyssen.
Meded K. Vlaamse Acad. Wetensch., Vol. 21, No. 5, 36 pp. (1959). In Flemish with summary ($1\frac{1}{2}$ pp.) In English.

Factors which control the formation and stability of foaming systems are reviewed, and the principal methods for measurement of "foaminess" are given. W.Go

541.1

4748 THEORETICAL AND EXPERIMENTAL STUDY OF SOME PROBLEMS OF ADSORPTION.
Mem. Soc. Roy. Sci. Liege (Ser. 5), Vol. 1, No. 3, 162 pp. (1958). In French.

A diode apparatus and the method of measurement of the variation of internal electrical resistance were used in the experimental determination of adsorption. Details of the control technique adopt are also given. Experimental results on the adsorption of hydroger on pure metallic surfaces ($Pt-H_2$ and $W-H_2$ systems) are presente and discussed, the data being compared with existing literature. Finally, there is a long theoretical treatise of adsorption on metall surfaces and of the interpretation of the results in terms of the geometry of the crystalline faces and the stoichiometry of the hydroge film. Very extensive reference lists are given throughout.

G.I.W.Llewel

541.1

4749 ABSORPTION OF HYDROGEN BY PALLADIUM AT LO TEMPERATURES. I.E.Nakhutin and E.I.Sutyagina.
Fiz. Metallov i Metallovedenie, Vol. 7, No. 3, 459 (1959). In Russian.

The absorption by Pd-black was measured as a function of pressure at $-78^\circ$, $-120^\circ$ and $-196^\circ$C. A.F.Brow

541.

4750 DETERMINATION OF THE AMOUNT AND COMPOSITION OF GASES ADSORBED ON THE SURFACE OF Ge AND Si MONOCRYSTALS BY MASS-SPECTROMETRY. V.M.Kozlovskaya.
Fiz. tverdogo Tela, Vol. 1, No. 7, 1027-34 (July, 1959). In Russia

It was established experimentally that gases which evolve fro Ge and Si were surface-adsorbed. Etching of Ge with $H_2O_2$ change only the value of the true surface (thus also the amount of adsorbe gases). In the case of Si the etching agents affect not only the true surface, but have also a selective influence on the adsorptive properties of the surface with respect to various gases. F.Lachma

## PHYSICAL METHODS OF CHEMICAL ANALYSIS

54

4751 ACOUSTIC GAS ANALYSER.
L.Molyneux.
J. sci. Instrum., Vol. 36, No. 3, 118-20 (March, 1959).

An instrument capable of measuring the concentration of halothane (bromochlorotrifluoroethane) or chloroform vapour over a range of 0-4% by volume, with an accuracy of $\pm\frac{1}{4}\%$, is described. The gas containing the vapour is a mixture of air and oxygen, and the instrument compares the time taken by a pulse of sound to travel through the original gas sample with the time taken for another pulse to travel through the same sample after the removal of the vapour by activated charcoal. Transistors are used throughout, and the instrument is small and self-contained.

545 : 533.7 : 53

4752 INCREASE OF THE SENSITIVITY OF THE OPTICO-ACOUSTIC METHOD OF GAS ANALYSIS BY THE USE OF CELLS EMPLOYING MULTIPLE PASSAGE OF RADIATION.
Ya.I.Gerlovin and P.V.Slobodskaya.
Optika i Spektrosk., Vol. 7, No. 1, 105-12 (July, 1959). In Russian

Discusses an optico-acoustic gas analyser with multiple-passage cells. Shows that the increase of the analyser sensitivity depends on the reflection coefficient of mirrors employed and on t igmatism of radiation beams. A relationship is obtained which es the optimum number of passages. Dependence of the analyser sitivity on the amount of gas in the comparison cell (filled with a -absorbing gas) is given. A.Tybulewicz

545

### 4753 USE OF THE SELECTIVE EMISSION OF A GAS IN INFRARED GAS ANALYSERS.

D.Sall' and S.B.Stanevich.

tika i Spektrosk., Vol. 7, No. 2, 256-8 (Aug., 1959). In Russian.

Describes how selective emission by a hot gas may be used stead of a source with a continuous spectrum; the use of a selective urce leads to an improved analyser selectivity. The selective urces were in the form of cylindrical chambers filled with the s (e.g. $CO_2$) whose concentration was to be determined in a given xture. The inner surfaces of the chambers were chromium-plated d polished. The gas in the chambers was heated to 86° C (the bient temperature was 20° C). A.Tybulewicz

545 : 535.8

### 4754 INFRA-RED ABSORPTIOMETER, USING INTERFERENCE FILTERS, FOR ANALYSIS OF HYDROGEN FLUORIDE GASEOUS MIXTURES.

J.A.Harrison and C.D.Reid.

sci. Instrum., Vol. 36, No. 5, 240-2 (May, 1959).

A wavelength-scanning absorptiometer using interference filters s been developed for analysis of hydrogen fluoride in corrosive s mixtures. The wavelength scanning is achieved by tilting an erference filter at 10 c/s, thus passing alternate beams of differ- wavelength through the same sample tube. Only one of the beams absorbed by HF, while the other is used as a reference beam; a ference signal depending on the partial pressure of HF is measured. ing this principle, the instrument has been designed so that the libration is independent of corrosion of the windows of the absorp- n tube. The prototype instrument detects partial pressures of drogen fluoride in the range 0.02-20 mm of mercury in 1 atm the mixture.

545

### 4755 MEASUREMENT OF RAPIDLY CHANGING OXYGEN CONTENT IN GAS MIXTURES BY ABSORPTION ECTROSCOPY IN THE SCHUMANN REGION.

Prugger and W.Ulmer.

angew. Phys., Vol. 11, No. 12, 467-70 (Dec., 1959). In German.

A $H_2$ lamp source and tungsten photocell are used, the windows each acting also as the end windows of a flow-through gas cell. e effective wavelength is 1580 A, where interference by $H_2O$ is nall, and by $CO_2$ and $N_2O$ negligible. The sensitivity is 1% of $O_2$ atmospheric pressure. Response time = 0.1 sec. G.F.Lothian

545

### 4756 ESTIMATION OF TRITIUM IN A PROPORTIONAL COUNTER.

W.G.Verly, G.Hunebelle and G.Thomas.

kleonik, Vol. 1, No. 9, 325-9 (Dec., 1959). In French.

A quantitative measure of tritium activity, accurate to 2%, is tained by introducing it in gaseous form into a Bernstein–Ballentine oportional counter. The partial pressure of tritium should not ceed 500 mm Hg and methane is then added to a total pressure of out 760 mm Hg. No contamination of the counter tube or filling stem by tritium has been observed. (See also following abstract). A.E.I. Research Laboratory

545

### 4757 ESTIMATION OF TRITIUM IN A PROPORTIONAL COUNTER. II. PREPARATION OF SAMPLES.

A.Ciccarone, G.Thomas and W.G.Verly.

kleonik, Vol. 1, No. 9, 329-32 (Dec., 1959). In French.

An organic compound containing tritium is burnt in a current of ygen and the water of combustion is transferred under vacuum to clean tube containing magnesium turnings. The tube is heated to 50° C for an hour and the tritium content of the hydrogen measured a proportional counter described previously (see preceding stract). It was verified that no gas other than the hydrogen from e specimen was evolved; the error involved in the measurement the tritium content was estimated to be about 1.5%. A.E.I. Research Laboratory

545

### 4758 ANALYSIS OF PERMANENT GASES BY GAS CHROMATOGRAPHY USING A RADIOACTIVE IONIZATION TYPE ETECTOR.

V.Willis.

ature (London), Vol. 184, 893-4 (Sept. 19, 1959).

The sensitivity of the radioactive ionization-type detector for gas chromatography is greatly increased by introducing a small continuous bleed of organic vapour into the argon carrier stream. With a concentration of ethylene in the detector of the order of 1 p.p.m., the minimum detectable concentrations of hydrogen, oxygen and methane were 0.5 p.p.m. and for nitrogen 1.0 p.p.m. Sensitivity is further increased by a factor of about seven when the ethylene concentration is at its optimum value (apparently about 100 p.p.m.). C.F.Barnaby

545 : 535.8

### 4759 AUTOMATIC SCANNER FOR ELECTROPHORESIS AND CHROMATOGRAPHY PAPER STRIPS.

G.Smiljanic and T.Rabuzin.

J. sci. Instrum., Vol. 36, No. 4, 160-3 (April, 1959).

A device for scanning electrophoresis and chromatography paper strips is described. A pen recorder traces the curves of the optical density, integral of the optical density, radioactivity intensity and integral of the radioactivity intensity as a function of position of the paper strip. The scanning is carried out automatically.

545

### 4760 APPARATUS FOR RECORDING POLAROGRAPHIC DISPLAYS.

H.Schmidt.

Z. InstrumKde, Vol. 67, No. 12, 301-10 (Dec., 1959). In German.

An illustrated survey of commercial equipment available for d.c., a.c. and c.r. polarography.

545

### 4761 THE X-RAY SCANNING MICROANALYSER.

P.Duncumb.

Brit. J. appl. Phys., Vol. 10, No. 9, 420-7 (Sept., 1959).

The chemical microanalysis of a surface by the Castaing technique is carried out by exciting characteristic X-ray emission from a selected point, located optically under a stationary electron beam about 1 $\mu$ in diameter. In many cases, the speed of working is greatly increased by the use of a scanning technique, which enables the surface distribution of a given element to be presented visually as an image on a cathode-ray tube screen. For quantitative analysis of a selected feature, accurate positioning of the beam may be carried out by reference to this image, or to a similar image showing topographical detail. The method has been applied to elements of atomic number 12 and above, in metallurgical, biological and mineralogical specimens. The principle, theory and design of an X-ray scanning microanalyser is described, and typical applications are illustrated by two examples.

545

### 4762 SIMPLE ELECTRONIC SCANNING SYSTEM FOR THE X-RAY MICROANALYSER.

A.Bernard, D.Bryson-Haynes and T. Mulvey.

J. sci. Instrum., Vol. 36, No. 10, 438-44 (Oct., 1959).

An electrostatic deflector system is described for use with the X-ray microanalyser. This enables the electron probe to be scanned across the specimen electrically using either manual or electronic control. The application of this system to a current metallurgical problem is described and certain statistical limitations of the method are mentioned.

545

### 4763 A CALIBRATION PROCEDURE IN THE QUANTITATIVE X-RAY FLUORESCENCE ANALYSIS OF SYSTEMS WITH SEVERAL COMPONENTS.

H.Preis and A.Esenwein.

Schweiz. Arch. angew. Wiss. Tech., Vol. 25, No. 11, 415-18 (Nov., 1959). In German.

A method of calibration is described by which fairly accurate analyses may be made of three-component alloys, using a single standard sample. Details are given for a type-metal alloy of Pb, Sb and Sn. S.T.Henderson

545 : 539.1.07

PROPORTIONAL COUNTERS IN X-RAY SPECTROCHEMICAL ANALYSIS. See Abstr. 3881

545

### 4764 ELECTRON DIFFRACTION AT NICKEL CATALYSTS.

S.Yamaguchi.

Z. phys. Chem. (Leipzig), Vol. 211, No. 5-6, 358-60 (1959). In German.

Uses electron diffraction patterns to draw conclusions about the state of oxidation of nickel particles of size about 500 A. E.P.Wohlfarth

545 : 621.365.41

4765 LINEAR VOLTAGE TEMPERATURE FURNACE FOR THERMAL ANALYSIS. A.J.Martin and K.L.Edwards.
J. sci. Instrum., Vol. 36, No. 4, 170-2 (April, 1959).

A furnace is described which may be operated in a vacuum or an inert atmosphere, and which was developed for thermal analysis studies of beryllium and its alloys. Extremely rapid heating and cooling rates may be employed if required, or, with slow heating and cooling rates, a linear variation in voltage with time will produce a correspondingly near-linear variation in temperature. This is of great value in thermal analysis work, and is very much cheaper than the electronic controllers or mechanical cam devices that are usually necessary.

545

4766 ESTIMATION OF TRACE WATER CONTENT IN A HALOGENATED OIL BY MEANS OF TRITIATED WATER. J.F.Cameron, I.S.Boyce and R.M.Glaister.
Brit. J. appl. Phys., Vol. 10, No. 10, 463-5 (Oct., 1959).

A simple but accurate method using tritiated water for determi ing the efficiency of a plant for drying a halogenated, hydrocarbon oil is described. By the use of tritiated water with an activity of 50 mc/ml., it is possible to measure water contents as low as 0.04 p.p.m., while, with an activity of 5 c/ml., the sensitivity may be increased to four parts in $10^{10}$. An advantage of the method is that the samples may be exposed to the atmosphere for short periods without appreciably changing the labelled water content.

545

4767 URANIUM ANALYSIS BY GAMMA ABSORPTIOMETRY. R.E.Connally.
Nucleonics, Vol. 17, No. 12, 98-100, 102 (Dec., 1959).

A 10 mg $Am^{241}$ source and a NaI crystal detector measures the concentration of uranium solutions with an accuracy of 0.15% over the range 25-100 g/litre of U. R.D.Smit

# GEOPHYSICS

550.3

4768 SEISMIC RECORDINGS OF LARGE EXPLOSIONS IN SOUTH-EASTERN AUSTRALIA.
H.A.Doyle, I.B.Everingham and T.K.Hogan.
Austral. J. Phys., Vol. 12, No. 3, 222-30 (Sept., 1959).

Three very large quarry explosions of between 50 and 100 tons of high explosive in the Snowy Mountains area were recorded by seismographs at distances up to 375 km. P and S wave velocities within the earth's crust for this part of south-eastern Australia were formally determined to be 6.04 (± 0.04) and 3.62 (± 0.03) km/sec, respectively. The $P_n$ velocity was found to be 8.03 km/sec, with an estimated error of 0.2 km/sec. Assuming a uniform layer above the Mohorovicic discontinuity with these velocities, the discontinuity was formally estimated to be at a depth of 37 km.

550.3 : 539.1

4769 ON THE SEISMOLOGICAL ASPECTS OF THE 1954 HYDROGEN BOMB EXPLOSIONS.
T.N.Burke-Gaffney and K.E.Bullen.
Austral. J. Phys., Vol. 11, No. 3, 318-21 (Sept., 1958).

Tentative conclusions previously drawn from an analysis of seismic readings of four 1954 hydrogen bomb explosions are re-examined in the light of source data subsequently released on these explosions. The released data show that the author's earlier computed origin-times for the four explosions were correct within 0.0, 0.4, 0.7 and 0.1 sec respectively. The re-examination shows that the Jeffreys—Bullen P tables need a correction of −2.2 ± 1.0 sec for surface epicentres in the mid Pacific and recordings at continental stations. It is confirmed that any difference between the P travel-times from Bikini to Australia and Bikini to the United States is not much more than $\frac{1}{2}$ sec. The authors' previous inferences on the velocities of air waves from the explosions remain undisturbed. The re-examination confirms the occurrence of diffracted PKP waves in front of the 142° caustic, and confirms that these diffracted waves arrive at times significantly earlier than PKIKP waves.

550.3 : 538.3

4770 MAGNETIC EFFECTS RESULTING FROM TWO HIGH-ALTITUDE NUCLEAR EXPLOSIONS.
J.A.Lawrie, V.B.Gerard and P.J.Gill.
Nature (London), Vol. 184, B.A.34, B.A.51-B.A.52 (Sept. 5, 1959).

Magnetic variations in H and D are interpreted in terms of a four-phase mechanism: a hydrodynamic impulse affected by dispersion, transport of individual $\beta$-particles, photo-electrons and possibly ions, followed by gas motion with suitable boundary conditions and the later formation of a shock front. S.J.St-Lorant

550.3

4771 SOME GEOMAGNETIC PHENOMENA ASSOCIATED WITH NUCLEAR EXPLOSIONS.
R.G.Mason and M.J.Vitousek.
Nature (London), Vol. 184, B.A.52-B.A.54 (Sept. 5, 1959).

The magnetograms from 3 stations in the vicinity of Christmas Island show pronounced variations in Z and D some minutes after the explosion of a low-altitude nuclear device on April 28, 1958. No variations in H are observed. Mechanisms producing such disturbances are suggested but it is noted that probably several separate mechanism are involved. S.J.St-Lora

550.

4772 A STUDY OF THE GEOMAGNETIC FIELD IN THE 5-50 c/s BAND.
R.Benoit and Tran The Hien.
C.R. Acad. Sci. (Paris), Vol. 250, No. 5, 893-5 (Feb. 1, 1960).
In French.

Gives the details of a study of the rapid, micropulse variations in the intensity of the earth's magnetic field in the region of Saigon S.J.St-Loran

550

4773 EXCHANGE INTERACTION AS A CAUSE OF REVERSE THERMO-REMANENT MAGNETISM.
T.Nagata and S.Uyeda.
Nature (London), Vol. 184, 890-1 (Sept. 19, 1959).

Discusses the property of reverse thermo-remanent magnetis peculiar to the ilmenite-haematite series in terms of an exchange interaction across the boundary between two connected phases, in this case the ferrimagnetic and antiferromagnetic border region occupied by certain members of the series. S.J.St-Loran

550

4774 ON MAGNETIC STABILITY OF ROCKS. (THE INFLUENCE OF THE COERCIVE FORCE ON THE STABILITY OF ROCKS. G.N.Petrova.
Ann. Geophys., Vol. 15, No. 1, 60-6 (Jan.-March, 1959).

550

4775 ON THE THEORY OF THE GEOMAGNETIC SECULAR VARIATION. S.K.Runcorn.
Ann. Geophys., Vol. 15, No. 1, 87-92 (Jan.-March, 1959).

A basic assumption made in the interpretation of the direction of magnetization of rocks, which are the presumed directions of the field at the times of the formation of the rocks, is that the mea direction of the field over times long compared with the periods of the secular variation is that of a geocentric dipole oriented along the axis of the earth's rotation. The relative rotation of the core a mantle, inferred from the westward drift of the geomagnetic field and the irregular fluctuations of the length of the day, is shown to imply that, even if a permanent non-dipole field could be generated the core, the non-axial parts would be averaged out by observation over a long time at the earth's surface. The relative rotation is al shown to give an explanation for the clockwise rotation of the geomagnetic field vector observed at points on the earth's surface wh is found when observatory records are available over a long perio of time.

550.3 : 5

SPINNER-MAGNETOMETER FOR THERMAL DEMAGNETIZATION EXPERIMENTS ON ROCKS. See Abstr. 3829

550.3

4776 VELOCITIES OF LONGITUDINAL WAVES IN THE UPPER PART OF THE EARTH'S MANTLE.
ehmann.
. Geophys., Vol. 15, No. 1, 93-118 (Jan.-March, 1959).

The investigation deals with Europe only and recalls the com-kity of its structure. Because the P time—distance curve is now en to be nearly a straight line up to about $15^0$ epicentral distance, velocity at depth cannot be derived from it by the direct method, by trial and error a possible solution is obtainable. The velocity dient has to be taken quite small, or as zero, in an upper layer. s is taken to extend to 220 km depth and an abrupt increase of ocity and velocity gradient to set in at this depth. From about onwards, the P curve becomes associated with waves refracted he deeper layer. With the velocities adopted, the corresponding urve is, up to $22^0$, in good agreement with Jeffreys' revised 4 curve. The properties of P and pP curves of shocks having ir foci at some depth in the upper layer are considered. Some p Rumanian earthquakes all from the same focus are examined l their P times compared with those calculated. Some deviations med explainable only as due to local differences of structure. leep earthquake in the Tyrrhenian Sea is also examined. The pted solution seems a possible one, but it is not unique and more ervations are required. More precise determinations of ampli-e variation would be particularly useful.

550.4 : 539.16

4777 A POSSIBLE GEOCHEMICAL APPLICATION OF KRYPTON-85. S.Amiel and L.Winsberg.
nuclear Energy, Vol. 5, No. 1, 50-1 (1957).

A method for estimating the size of uranium ore deposits from $Kr^{85}$ transported by water or gases from the deposit.

## ATMOSPHERE . IONOSPHERE

*(Abstracts on radiowave propagation in ionized media will also be found under Electromagnetic Waves)*

551.5

4778 WIDE RANGE RECORDING ANEMOMETER.
A.N.Rapsey.
sci. Instrum., Vol. 36, No. 2, 63-6 (Feb., 1959).

Uses optical linkages to measure wind speeds from 2 to ) miles/hr and wind direction to within $\pm 2^0$. The output is in the m of pulse-modulated signals suitable for counting directly or recording on magnetic tape.

551.5 : 53

STRIP CHART RECORDER FOR METEOROLOGICAL EASUREMENTS. See Abstr. 3436

551.5

4779 METHOD FOR MEASURING THE MOISTURE CONTENT OF AIR. J.Higgins.
sci. Instrum., Vol. 36, No. 7, 300-2 (July, 1959).

The water vapour in a sample of air is first condensed as ice d subsequently allowed to evaporate at room temperature, so using a pressure rise in a closed, evacuated system, the pressure ing measured by a simple oil manometer. The apparatus for doing is is described in detail and, by a calibration of the instrument th known masses of water vapour, a factor can be obtained that nverts the observed vapour pressure to absolute humidity with an erall accuracy better than 1%. The apparatus has also been used study the relationship between water vapour pressure e (mm of ercury) and absolute humidity $h_v$(g/m$^3$). A value of 286.4 ± 1.7 as obtained for the constant C in the equation $h_v = Ce/T$ where T as the absolute temperature ($^0$K).

551:5

4780 CONTRIBUTION TO THE STUDY OF THE PROBLEM OF ACTINOMETRIC METHODS. R.Pastiels.
ubl. Inst. Roy. Meteorol. Belgique A, No. 11, 128 pp. (1959).
French.

Monograph in four sections. Chapter 1 deals with the geo-etric method applied to the basic characteristics of actinometers: Chapter 2 gives a theoretical treatment of the problem of circumsolar light in direct actinometry: Chapter 3 discusses the use of the results obtained in the first two chapters to evaluate approximate sky-corrections for the principal actinometers in present use: Chapter 4 describes various receptor systems in current use; and their influence on the degree of precision attainable in practice. A bibliography of 44 references is appended. D.R.Barber

551.5

4781 SOLARIMETER FOR FIELD USE.
J.L.Monteith.
J. sci. Instrum., Vol. 36, No. 8, 341-6 (Aug., 1959).

Using simple materials a thermopile solarimeter has been constructed with output 5.5 mV cal$^{-1}$ cm$^{-2}$ min$^{-1}$; resistance 13 Ω; response time 20 sec; weight 35 g; dimensions 4 × 4 × 4 cm. It can therefore be used with a portable millivoltmeter for measuring reflection coefficients, radiation within crops, etc. General equations for solarimeter performance and a simplified theory for the present design give a non-linearity of −0.8% cal$^{-1}$ cm$^{-2}$ min$^{-1}$ and a temperature coefficient of −0.12% per deg C. Outdoor comparison with a Kipp solarimeter gave ± 0.03 cal cm$^{-2}$ min$^{-1}$ as the maximum deviation from the mean response with radiation up to 1.1 cal cm$^{-2}$ min$^{-1}$. The standard deviation for thirty observations in bright sunshine and with overcast skies was ± 0.002 cal cm$^{-2}$ min$^{-1}$. Cosine and azimuth response were improved using a larger instrument of the same design and comparisons of this with a Kipp solarimeter gave maximum deviation of ± 0.02 cal cm$^{-2}$ min$^{-1}$.

551.5

4782 IMPROVED POLYTHENE-SHIELDED NET RADIOMETER.
J.P.Funk.
J. sci. Instrum., Vol. 36, No. 6, 267-70 (June, 1959).

An improved net radiometer using very thin hemispherical polythene windshields is described. Balanced radiant heating of the windshield prevents formation of dew. Two of these instruments, suitably matched, permit direct measurements of radiative flux divergence in the lowest few metres of the atmosphere, with an accuracy of at least 10%. Some preliminary results are given.

551.5

4783 TWO INSTRUMENTS FOR ATMOSPHERIC OPTICS MEASUREMENTS. B.S.Pritchard and W.G.Elliott.
J. Opt. Soc. Amer., Vol. 50, No. 3, 191-202 (March, 1960).

A description is given of the design and construction of two instruments for studying atmospheric optics. One device, the Recording Polar Nephelometer, measures the volume scattering index of light passing through a sample of natural atmosphere, with scattering angle, polarization, and wavelength as variables. A new calibration procedure has been developed which employs a diffusing screen of known reflectance and transmittance as the standard. The second device, the Portable Tranmissometer, measure the extinction coefficient with an accuracy of 5% under all conditions. These instruments are transported by a specially-equipped station wagon to form a mobile research unit. Samples of results obtained in fog and clear air are included.

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4784 RADIOSONDE MEASUREMENT OF VERTICAL ELECTRICAL FIELD AND POLAR CONDUCTIVITY.
O.C.Jones, R.S.Maddever and J.H.Sanders.
J. sci. Instrum., Vol. 36, No. 1, 24-8 (Jan., 1959).

A field mill and a Gerdian type of conductivity apparatus are described which can replace two standard units on a slightly modified Kew Mk. II radiosonde. They are particularly suitable for an investigation of the electrical properties of the lower atmosphere, including clouds, in non-stormy conditions. Part of each device consists of a current-controlled inductor which varies the frequency of the sonde signal. The limitations and temperature effects are briefly discussed, and the results of a typical sounding given.

551.5.

4785 MEASUREMENT OF THE ATMOSPHERIC ELECTRIC FIELD IN THE FREE ATMOSPHERE.
R.Mühleisen and H.J.Fischer.
Naturwissenschaften, Vol. 47, No. 2, 36-7 (1960). In German.

Describes some measurements at heights between 5 and 32 kilometers, using a radiosonde. J.Hough

551.5

4786 DETERMINATION OF ATMOSPHERIC EXTINCTION FOR 20 AND 3.2 cm WAVELENGTHS. F.Fürstenberg.

Z. Astrophys., Vol. 49, No. 1, 42-60 (1960). In German.

Measurements of atmospheric extinction in the radio-spectrum made with tuned dipole receivers at the foci of 8, and 2.5 m parabolic reflectors, gave average extinction coefficients (for vertical incidence) of 0.072 dB at λ = 20 cm, and 0.084 dB at λ = 3.2 cm respectively. D.R.Barber

551.5 : 525

### 4787 DENSITY OF THE UPPER ATMOSPHERE FROM ANALYSIS OF SATELLITE ORBITS: FURTHER RESULTS.

D.G.King-Hele.

Nature (London), Vol. 184, 1267-70 (Oct. 24, 1959).

The method of determining air density from the rate of contraction of satellite orbits has been refined by taking account of atmospheric rotation. Results from 15 satellites are considered, and give a consistent measure of air density at heights between 180 and 700 km. There is some indication of a peak in temperature near the 220 km level. Density variations with latitude or season are less than a factor of 1.5, but there is some evidence of a night-to-day variation. H.J.A.Chivers

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### 4788 MEASUREMENTS OF TURBULENCE IN THE UPPER ATMOSPHERE.

J.S.Greenhow and E.L.Neufeld.

Proc. Phys. Soc., Vol. 74, Pt 1, 1-10 (July, 1, 1959).

The structure of turbulence in the 80-100 km region above the earth has been investigated by the simultaneous measurement of wind velocities at two points along a meteor trail. The fall off in correlation between the wind velocities at the two points, as their separation is increased, has been used to obtain a measure of the eddy size. The turbulence is found to be distinctly anisotropic, the vertical scale of the large eddies being 7 km whilst their horizontal extent is of the order of 150 km. The size of the smallest eddies is found to be approximately 50 m. Mean wind shears of 10 m $sec^{-1}$ $km^{-1}$ are found with a maximum of 140 m $sec^{-1}$ $km^{-1}$. No significant difference between day and night time turbulence is found.

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### 4789 SPECTRAL DETERMINATION OF THE HUMIDITY OF AIR IN THE UPPER LAYERS OF THE ATMOSPHERE.

M.S.Kiseleva, B.S.Neporent and V.A.Fursenkov.

Optika i Spektrosk., Vol. 6, No. 6, 801-3 (June, 1959). In Russian.

A diffraction-grating spectrometer was used to deduce the humidity of the atmosphere from attenuation of solar radiation in the regions of absorption by water at 1.4, 1.9 and 2.6 $\mu$. The instrument was made as light as possible and was sent up in a balloon on various occasions in 1955-7. It was found that between 3 and 11 km there were 0.15-0.50 mm of condensed water per 1 km of height. A.Tybulewicz

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### 4790 DIRECTIONAL OBSERVATIONS OF RADIO NOISE FROM THE OUTER ATMOSPHERE.

G.R.A.Ellis and D.G.Cartwright.

Nature (London), Vol. 184, 1307-8 (Oct. 24, 1959).

Direction finding apparatus has been set up in order to try to locate the origin of very low frequency (4.5 kc/s) emissions associated with geomagnetic field disturbances. Most disturbances seem to come from north or south and the angular size of the sources has been estimated at between 30° and 70°. H.J.A.Chivers

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### 4791 DOPPLER-SHIFTED CYCLOTRON FREQUENCY RADIATION FROM PROTONS IN THE EXOSPHERE.

W.B.Murcray and J.H.Pope.

Phys. Rev. Letters, Vol. 4, No. 1, 5-6 (Jan. 1, 1960).

It has been suggested that "dawn chorus" may be due to Doppler shifted radiation from protons which are rotating about the lines of force of the earth's magnetic field. A model frequency-time curve has been constructed for geomagnetic latitude 65°, assuming a specified electron density profile. The derived curve is remarkably similar to dispersion curves commonly obtained in practice. H.J.A.Chivers

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### 4792 INADEQUACY OF SCATTER MECHANISMS IN TROPOSPHERIC RADIO PROPAGATION.

P.C.M.de Belatini.

Nature (London), Vol. 184, 1558-9 (Nov. 14, 1959).

Although it is now well established that far beyond the horizon the propagation field of v.h.f. and u.h.f. radio waves is randomly distributed in time, suggesting a tropospheric scatter mechanism, the distribution in space is found to be coherent rather than random, a complex interference pattern arising from multipath propagation. A new theory of tropospheric propagation is being developed which attributes it to refraction in lens-like toroidal "Benard cells" in the atmosphere. G.M.Brow

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### 4793 SPACED OBSERVATIONS OF RADIO NOISE FROM THE OUTER ATMOSPHERE.

G.R.A.Ellis, D.G.Cartwright and J.R.V.Groves.

Nature (London), Vol. 184, 1391-2 (Oct. 31, 1959).

Simultaneous recordings of atmospheric radio noise at a frequency of 4.5 kc/s have been made at two stations in Australia, 1000 km apart. Results indicate that, in general, bursts occur simultaneously at the two sites, rather than at the same local times. However, a distinct time delay was found for the one occasion on which a burst was observed during a major geomagnetic storm and aurora. G.M.Brown

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### 4794 SOLAR ECLIPSE OF 30TH JUNE, 1954 AND ITS EFFECT UPON THE IONOSPHERE.

S.N.Mitra.

Indian J. Phys., Vol. 31, No. 6, 309-23 (June, 1957).

Experimental investigations to determine the effect of the total eclipse of the sun of 30.6.54, are described. The investigations were: (1) vertical incidence ionospheric measurements at Delhi, Srinagar and Bombay, (2) recording of the variation of short wave signals from the B.B.C. and Moscow at Delhi, (3) recording of field strength variation of medium wave signals from Jullundur at Delhi, (4) measurement of ionospheric absorption at vertical incidence using pulsed transmissions by means of an automatic absorption recorder at Delhi, and (5) recording of solar radio noise on 204 Mc/ at Delhi. The effect of the optical eclipse on the ionospheric layers could not be definitely established, due probably to the eclipse occurring around sunset when most of the optical effect was likely to be obscured. But evidence of three distinct "corpuscular eclipses" was obtained both on the ionization density of the F-layer and on the absorption in the non-deviating region. These were found to occur 2, 4 and 6½ hours before the optical eclipse. Theoretical arguments and past observations indicate that these corpuscular emissions may have originated from the so-called M-region of the sun.

551.5 : 539.1

### 4795 A STUDY OF THE ABSORPTION FREQUENCIES OF NEGATIVE MOLECULAR OXYGEN IONS IN THE FREQUENCY RANGE 3 TO 44 Mc/s.

T.V.Ionescu and O.C.Gheorghiu.

Rev. de Physique (Bucarest), Vol. 4, No. 2, 113-52 (1959). In Frenc

As part of a study of the fundamental electrical processes occurring in the ionosphere, the following radio-frequency phenomen occurring in ionized oxygen in air, oxygen and an air-neon mixture have been examined at various pressures: strong coupling in the gas; the absorption frequencies of the system; and luminous phenomena. The apparatus constructed for these measurements, a conventional radio-frequency spectrometer, is described in detail, and the observed results discussed. S.A.Aher

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### 4796 THE D REGION OF THE IONOSPHERE.

B.Bjelland, O.Holt, B.Landmark and F.Lied.

Nature (London) Vol. 184, 973-4 (Sept. 26, 1959).

Ionospheric cross-modulation measurements, using a pulse technique, were made in conjuction with a study of polar radio blackouts. From a preliminary analysis, some electron density profiles are given. H.J.A.Chiver

551.5

### 4797 TIDES IN THE F2 IONOSPHERIC LAYER.

P.Herrinck.

Nature (London), Vol. 184, 1055-6 (Oct. 3, 1959).

Harmonic analysis of the mean diurnal variation of the half thickness of the F2 layer has been worked out. The first harmonic term is prominent with the third, fifth, second and fourth in decreasing order of importance. Some seasonal and sunspot cycle variations are given. H.J.A.Chiver

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### 4798 DISTURBANCE IN THE IONOSPHERIC F-REGION FOLLOWING THE JOHNSTON ISLAND NUCLEAR PLOSION.

C.H.Cummack and G.A.M. King.
ure (London), Vol. 184, B.A.32-B.A.33 (Sept. 5, 1959).

Following high-altitude nuclear explosions, the F-region ical frequency first increased substantially, then decreased to p as a new layer formed at a height of 560 km. This F-region urbance also affected the magnetic records of several obser- ories at a time depending on the range to the explosion centre. authors suggest that a shock wave originating in the explosion sed an increase in ionization by collision and the subsequent in the critical frequency was due to recombination processes . region of relatively high gas pressure. H.J.A.Chivers

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### 4799 GEOMAGNETIC AND IONOSPHERIC PHENOMENA ASSOCIATED WITH NUCLEAR EXPLOSIONS.

atsushita.
ure (London), Vol. 184, B.A.33-B.A.34, (Sept. 5, 1959).

Ionospheric disturbances revealed by ionosonde records and gnetograms, indicate that a counterclockwise electric current tem was set up in the vicinity of the explosions. The direct ects appeared to be confined over an area in the central Pacific. height at which the nuclear explosions occurred has been cal- ated from the geophysical effects, and it is noted that none of a r series of high altitude (480 km) detonations was followed by ilar events. H.J.A.Chivers

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### 4800 THE EFFECT OF SUDDEN IONOSPHERIC DISTURBANCES (S.I.D.'S) ON 2.28 Mc/s PULSE FLECTIONS FROM THE LOWER IONOSPHERE.

F.F.Gardner.
stral. J. Phys., Vol. 12, No. 1, 42-53 (March, 1959).

The effects of sudden ionospheric disturbances (S.I.D.'s) on the mplicated structure of ionospheric echoes obtained with moder- ely high sensitivity at 2.28 Mc/s are described. The observations icate that flares of classes 2 and 3 can produce high values of ectron density near the base of the ionosphere. Mean electron nsity can exceed 1000 per cm$^3$ over the height range 60-75 km, ere the greatest relative increase in ionization occurs. Never- eless, the greater part of the S.I.D. absorption of waves reflected om the E region or above still occurs above 85 km. The times maximum disturbance at the different ionospheric levels agree thin the experimental limit of about 1 min. The times of subse- ent recovery at levels up to 85 km also seem to be simultaneous. owever, the recovery of the E echo lags behind that of the -90 km echo group, by about 4 min on the average for large I.D.'s. It is quite likely that the delay is not wholly due to fferent recombination rates at different ionospheric levels, but partly caused by a change in the quality of the incoming solar diation during the life of the flare.

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### 4801 MODELS OF THE LOWER IONOSPHERE AS MAY BE INFERRED FROM ABSORPTION RESULTS.

Bandyopadhyay.
dian J. Phys., Vol. 31, No. 6, 297-308 (June, 1957).

Values of deviative and non-deviative absorption and their ariations with cos $\chi$ are calculated for some of the proposed D nd E region models. The results obtained are compared with the vailable experimental data. It is found that so far as the E region concerned, Mitra's (1954) theoretical model is most consistent ith the observed diurnal variation of absorption. For the E region, e model, as proposed by Jones (1955), is found to be unacceptable. onditions which are to be satisfied by an acceptable E region model re discussed.

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### 4802 THE SODIUM TWILIGHT AIRGLOW 1955-1957. I.

J.E.Blamont, T.M.Donahue and V.R.Stull.
nn. Geophys., Vol. 14, No. 3, 253-81 (July-Sept., 1958).

An analysis of twilight observations made at the Observatoire Haute-Provence is presented. During 1955 and 1956 the emission tensity to the west of the observatory was stronger (by a factor of 43) than that to the east. Large changes in the W/E ratio could ccur in 12 hr and a high value of the ratio maintained for a week or ore. Agreement with the theory of resonance absorption in the lluric layer is found, leading to a deduction of Na abundances varying between $2 \times 10^9$ and more than $30 \times 10^9$ atoms/cm$^2$. Minimum values occur in summer, maxima in November-December and March. The influence of the Doppler effect for the solar D lines and the asymmetrical east—west distribution on the morning—evening intensity ratios is discussed.

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### 4803 THE SODIUM TWILIGHT AIRGLOW 1955-1957. II.

J.E.Blamont, T.M.Donahue and W.Weber.
Ann. Geophys., Vol. 14, No. 3, 282-304 (July-Sept., 1958).

The measurements discussed in the previous abstract are analysed to determine the height and vertical distribution of sodium. Since the measurements were made in three directions for each twilight, they can yield information about the height of the sodium and the distance between the sodium and screening layers separately. However, care must be exercised to correct the observations for multiple scattering, the instrumental solid angle and azimuth setting. The measurements then yield 87.9 ± 0.4 km for the average altitude of the sodium layer and 29.5 ± 0.8 km for the screening layer. A correlation between ozone and sodium altitude is found, together with evidence for a tendency of both layers to be higher when the intensity is higher. A study of the shape of the cut-off at the end of twilight indicates that the sodium layer is usually about 14 km wide, but narrower in the evening than in the morning.

551.5

### 4804 ON THE INTENSITY AND POLARISATION OF THE LIGHT FROM THE SKY DURING TWILIGHT. II.

J.V.Dave.
Proc. Indian Acad. Sci., A, Vol. 43, No. 6, 336-58 (June, 1956).

A continuation of previous work (Abstr. 8524 of 1956). In the present paper the formulae of Chapman and Hammad (1939) are modified, and applied to the problem of the secondary scattering of residual sunlight in twilight in which the curvature of the atmosphere is of fundamental importance. The intensity and polarization of the zenith sky are computed for various values of solar zenith distance from 90 to 107 degrees. A radiation wavelength is taken for which the optical thickness of the atmosphere is 0.2. Calculated values are compared with observational data obtained at Mount Abu, and presented in the earlier paper. D.R.Barber

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### 4805 EXTREME ULTRAVIOLET RADIATION IN THE NIGHT SKY.

J.E.Kupperian, Jr, E.Byram, T.A.Chubb and H.Friedman.
Ann. Geophys., Vol. 14, No. 3, 329-33 (July-Sept., 1958).

A directional survey was made from an Aerobee rocket (NRL-31, 2200, March 28, 1957) using collimated photon counters and ion chambers sensitive in the 1040-1350 A region. Discrete sources of radiation were observed in the 1225-1350 A region, which in most cases could be identified with known celestial objects. In contrast, a diffuse and quite intense radiation was observed in the 1040-1225 A region. This radiation has been identified by its atmospheric absorption as the Lyman $\alpha$-line of hydrogen. The spatial distribution of this radiation as mapped by the spinning and yawing rocket was obtained for about 50% of both the upper and lower hemispheres. Two features of this distribution are of prime interest. The radiation from above showed a pronounced minimum which was symmetrical about the anti-solar direction. Radiation was also observed from the field of view below the rocket. This radiation when viewed from above 120 km was uniformly distributed and was about 42% of the average intensity from above. The results are interpreted as evidence for atomic hydrogen both in the solar system external to the earth's orbit and in the D and E regions of the atmosphere.

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### 4806 THE ALTITUDES AND EXCITATION MECHANISMS OF THE NIGHT AIRGLOW.

A.Dalgarno.
Ann. Geophys., Vol. 14, No. 3, 241-52 (July-Sept., 1958).

Review. 99 references.

551.5

### 4807 UNEXPECTED BEHAVIOUR OF THE RED LINE IN THE NIGHT SKY NEAR TO THE EQUATOR.

A.Delsemme and D.Delsemme.
C.R. Acad. Sci. (Paris), Vol. 250, No. 2, 383-5 (Jan. 11, 1960).
In French.

The red O I doublet at 6300, 6364 A was observed from a tropical station (Lwiro, Central Africa) over a period of 17 months. On several occasions, chiefly during the period November to May, the two lines were strongly enhanced near midnight. Normally, these lines are enhanced during twilight: the mechanism of the nocturnal increase remains unexplained. D.R.Barber

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### 4808 RESULTS FROM STUDIES OF THE NIGHT AIRGLOW AND AURORAE IN THE U.S.S.R.

V.I.Krassovsky, G.I.Galperin, A.V.Mironov, V.S.Prokudina, N.N.Shefov, N.I.Fedorova and B.A.Bagariazky.

Ann. Geophys., Vol. 14, No. 3, 356-67 (July-Sept., 1958).

Equipment used at the Institute of Atmospheric Physics and its various stations is briefly discussed. The following observational data are considered in some detail: auroral H emission (Loparskaya: $\Phi = 63^\circ 38'$, $\Lambda = 126^\circ 43'$); night airglow spectra and aurorae (Zvenigorod: $\Phi = 51^\circ 03'$, $\Lambda = 120^\circ 16'$); hydroxyl emission (Burokan, Armenia); relative intensity of $N_2$ and $N_2^+$ i.r. bands in auroral emissions (Murmansk).

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### 4809 EXISTENCE OF AN INNER AURORAL ZONE.

K.Lassen.

Nature (London), Vol. 184, 1375-7 (Oct. 31, 1959).

Visual auroral data from stations at high latitude indicate the existence of an inner auroral zone corresponding to that predicted by Alfvén. In the main auroral zone, the diurnal maximum in the occurrence of aurorae is at midnight, but the inner zone has a maximum at 06 hr L.T. Observations from a particular station fit a diurnal distribution which shows both maxima, but the relative amplitude of the two peaks depends on the latitude of the station. H.J.A.Chivers

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### 4810 STUDIES ON THE EXCITATION OF AURORA BOREALIS. II. THE FORBIDDEN OXYGEN LINES.

A.Omholt.

Geofys. Publ., Vol. 21, No. 1, 38 pp. (Sept., 1959).

For Pt I, see Abstr. 791 (1960). Excitation and deactivation of the forbidden oxygen lines is studied theoretically with emphasis on excitation by secondary electrons and discharge mechanisms. The computed value of the intensity ratio I (5577)/I(4709) for the excitation by secondary electrons is of the same order of magnitude as observed in aurorae. Discharge mechanisms are probably not able to contribute significantly to the auroral excitation, but the possibility that the horizontal currents responsible for the magnetic perturbations associated with aurorae contribute to some extent cannot be dismissed. Other indirect excitation mechanisms and deactivation mechanisms for the excited atoms are briefly reviewed. The intensity ratio I(5577)/I(4709) in aurorae was measured with a photoelectric photometer and found to be constant within ± 25% in all the forms measured. Rapid fluctuations in the intensities of the green [O I] line and the First Negative $N_2^+$ bands have been studied, and the lifetime $\tau$ of the $O(^1S)$ atoms has been computed by various methods. The lifetime appears to be 0.7 ± 0.1 sec. The detailed interpretation depends on the true value of the lifetime of the undisturbed $O(^1S)$ atoms, but the available evidence suggest that collisional deactivation sometimes occur, the lifetime of the undisturbed atoms being about 0.75 sec, and the probability of deactivation being in the range 0-1 per sec. This implies a probability of deactivation per gas kinetic collision of the order of magnitude $10^{-4}$. The importance of the various excitation mechanisms is discussed in the view of the measured lifetimes. Excitation by secondary electrons seems to be consistent with the observations. The red doublet is briefly discussed. There are not necessarily any inconsistencies between theory and observations, but the relevant data are too inaccurate to justify detailed discussions and definite conclusions. New observations on aurorae can yield only limited information until knowledge about the basic processes is improved by theoretical or laboratory investigations.

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### 4811 HYDROGEN EMISSION AT THE FINAL STAGE OF THE AURORA.

A.E.Veller.

Ann. Geophys., Vol. 14, No. 3, 323-5 (July-Sept., 1958).

The H$\alpha$ emission close to the auroral zone was studied with a grating spectrograph f/1.2 (335 A/mm). Systematic presence of the hydrogen emission was manifest in weak spectra at the final stage of the aurora.

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### 4812 COLOUR PHOTOGRAPHY OF THE AURORA.

B.P.Sandford and P Heiser.

Nature (London), Vol. 184, 540 (Aug. 15, 1959).

Previous technical difficulties experienced when attempting colour photography of auroral displays have been overcome by the introduction of the ultra-rapid daylight colour film, Super Anscochrome. Using an all-sky camera with F/1.4 lens, well-balanced records were obtained at Scott Base, Antarctica, in May-June, 1959, with exposure times of up to 2 minutes. With the latter, an aurora just detectable to the eye of an experienced observer, i.e., below the threshold of human colour vision, is recorded in a wide range of colours. Concurrent spectrographic tests confirm the reality of the colour distribution recorded by the new film. D.R.Barber

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### 4813 THE AURORA, THE RADIATION BELT AND THE SOLAR WIND: A UNIFYING HYPOTHESIS.

M.H.Rees and G.C.Reid.

Nature (London), Vol. 184, 539-40 (Aug. 15, 1959).

A recent study of the latitude drift of auroral H emission, as revealed by high time-resolution spectrograms obtained at College, Alaska, U.S.A., shows that this characteristic movement can be explained in a semi-quantitative way by examining the interaction of the incoming solar particle streams (the so-called "solar wind") and the trapped Van Allen radiation. If a moderate particle stream density is assumed, the expected drift of Van Allen particles due to the disturbed geomagnetic field is found to correspond closely to the observed drift of the auroral emission. It appears that the particles responsible for initiating the auroral display do not originate directly from the solar streams, but are remnants of earlier streams, trappe in the earth's field, that have spilled over from the Van Allen belt by an increase of solar wind strength on the sunward side of the earth. D.R.Barber

551.5 : 550.3

### 4814 DIURNAL VARIATION OF AURORA AND GEOMAGNETIC DISTURBANCE AT NEW ZEALAND ANTARCTIC STATIONS.

T.Hatherton and G.G.Midwinter.

Nature (London), Vol. 184, 889-90 (Sept. 19, 1959).

Separate visual and photographic studies of the diurnal variation of auroral frequency at Antarctic stations during the I.G.Y. give comparable results, and show the same form of variation at Scott Base and at Hallett Station with primary morning maxima and secondary evening maxima. Comparison of auroral data with geomagnetic activity shows that although there is a relationship between them, the main features of the auroral frequency variation are caused by factors not related to local magnetic disturbance. G.M.Brown

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### 4815 LOW-FREQUENCY (100 kc/s) RADIO NOISE FROM THE AURORA.

R.L.Dowden.

Nature (London), Vol. 184, 803 (Sept. 12, 1959).

Observations of radio noise on a range of frequencies from 4.6 to 180 kc/s covering the band between normal "hiss" (audio frequencies) and "cosmic noise" at Hobart have revealed at least one occasion on which "hiss" occurred at frequencies up to 180 kc/s. This suggests that radio noise at such frequencies which is usually attributed to cosmic sources, might be hiss of terrestrial origin, generated in the upper atmosphere by auroral particles. G.M.Brown

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### 4816 PROTON FLUX DURING THE GREAT AURORA OF 3-4 SEPTEMBER, 1959.

D.E.Osterbrock.

Science, Vol. 131, 353-4 (Feb. 5, 1960).

Photoelectric measurements of the H$\beta$ intensity show that it continued to increase after a corona formed, and reached a maximum as the corona broke up into rays, decreasing rapidly to nearly zero within the next 10 minutes. The maximum flux of protons incident on the earth during the aurora, deduced from these measures, was at least $1.4 \times 10^8$ auroral protons $cm^{-2}$ $sec^{-1}$.

551.5 : 621.391.81

### 4817 EFFECT OF ATOMIC TESTS ON RADIO NOISE.

C.A.Samson.

Nature (London), Vol. 184, 538-9 (Aug. 15, 1959).

Two high-altitude atomic explosions over Johnston Island in the tific, shortly after midnight on Aug. 1 and Aug. 12, 1958, appear have had a rather pronounced effect on the radio noise recorded Kekaha, Hawaii, about 700 miles N.W. of Johnston Island. In the r following the blast, the noise decreased by as much as 32 dB some frequencies at a time of day when it would normally be ing or holding steady. Recovery to normal levels apparently urred in a matter of hours at 13 kc/s and 5 Mc/s, but at 51, 160, kc/s and 2.5 Mc/s a changed pattern was evident for several rs, with levels at night much below normal. Similar effects were served in the case of the second explosion. The length of time r which there was an apparent increase in the night-time absorption noise suggests that high-altitude nuclear explosions may have a her persistent effect on radio communications at certain freencies.
A.Wilkinson

551.5 : 621.391.82

4818 OBSERVATIONS OF "WHISTLERS" AND VERY LOW FREQUENCY PHENOMENA AT GODHAVN, REENLAND. E.Ungstrup.

ture (London), Vol. 184, 806-7 (Sept. 12, 1959).

Preliminary analysis of whistler data obtained at Godhavn over period July 1957-July 1958 shows that, compared with obserions at lower latitudes, there is a lack of low frequencies inimum frequency ~5 kc/s) and a high "nose frequency" ~ 16 kc/s). This suggests that the whistlers penetrate the ionohere at about 27° south of Godhavn, and travel by waveguide opagation along the earth to the observation point. Some details observations of tweeks, chorus, and hiss are also given.
G.M.Brown

551.5 : 533.7 : 537.3

CONDUCTIVITY OF WEAKLY IONIZED AIR. See Abstr. 3730

551.5 : 538.3

STABILITY OF THE ADIABATIC MOTION OF CHARGED ARTICLES IN THE EARTH'S FIELD. See Abstr. 3837

551.5 : 539.16

4819 SIZE DISTRIBUTION OF RADIOACTIVITY OF THE NATURAL RADIOACTIVE DUST.

Kawasaki and K.Kato.

J. Phys. Soc. Japan, Vol. 14, No. 2, 234-5 (Feb., 1959).

Examination of the radioactive dust collected by a copper wire in the air near the ground, to which could be applied a high positive or negative potential, showed that the polarity of the collected particles was positive, and that the activities were due to RaB, RaC, and ThB. The particle size distribution of the activity was determined by passing air through an ion separator which transmitted only those ions with a mobility (related to size), less than a cut-off value dependent on the potential applied to the separator electrode. The particles were then electrostatically precipitated in a device which could also be used as a Geiger counter for detecting the activity.
R.E.Meads

551.5

4820 THE INFLUENCE OF ATOMIC EXPLOSIONS ON METEOROLOGICAL PROCESSES. E.K.Fedorov.

J. nuclear Energy, Vol. 5, No. 1, 135-45 (1957). English translation of article in: Atomnaya Energiya, Vol. 1, No. 5, 103 (1956).

The physical effects of atomic explosions on meteorological elements in the earth's atmosphere are considered. An analysis of the evidence shows that the thermodynamic effect of an explosion is insignificant, and cannot affect meteorological processes materially. Some changes of weather might result indirectly from a substantial modification of the electrical properties of the atmosphere and from the corresponding increase in condensation. To an order of magnitude, any such effects on the weather are comparable with those brought about by the periodic fluctuations in solar activity.

551.5

4821 SYNOPTIC STUDY OF THE VERTICAL DISTRIBUTION OF THE RADIO REFRACTIVE INDEX.

B.R.Bean, L.P.Riggs and J.D.Horn.

J. Res. Nat. Bur. Stand., Vol. 63D, No. 2, 249-54 (Sept.-Oct., 1959).

An analysis of the vertical structure of an intense outbreak of continental polar air is presented in terms of the radio refractive index of the atmosphere. Employed for the first time is a reduced index analogous to potential temperature. The reduced value more clearly shows the refractive index structure than the classical methods used heretofore. This new unit is a measure of both atmospheric density and humidity and shows, on a single cross-section, the airmass structure and the dynamic mixing of air around the frontal interface.

# BIOPHYSICS · PHYSIOLOGICAL PHYSICS

577.3 : 533.6

MEASUREMENT OF THE RATE OF WORK DONE AGAINST FRICTIONAL RESISTANCE IN BREATHING APPARATUS. See Abstr. 3554

## Hearing . Speech

612.8

4822 TEMPORAL IRREGULARITY OF EXCITATIONS : HOW MUCH IS ACCEPTED BY THE BRAIN FOR REPORTING PITCH. M.F.Meyer.

Acoust. Soc. Amer., Vol. 32, No. 3, 391-3 (March, 1960).

For many years the only obstacle standing in the way of crediting he theory of the hydraulic-cochlea model [American Journal of Psychology, Vol. 72, 293-6 (1959)] as a hypothetical "theory of hearing" has been the notion that the brain reports a pitch to conscious-sciousness only when it receives excitations from the auditory sense organ in strictest temporal regularity. The test of this notion has now been accomplished by experimenting with a siren — and the obstacle has been removed.

612.8

4823 AUDITORY PERCEPTION OF TEMPORAL ORDER. D.E.Broadbent and P.Ladefoged.

J. Acoust. Soc. Amer., Vol. 31, No. 11, 1539 (Nov., 1959).

Experiments showed that the perception of the time order of two stimuli presented in the same single sample was only possible when the onset of the components was separated by greater than 150 msec. With training, the threshold fell to the order of magnitude found by Hirsh (Abstr. 10474 of 1959). The relation of this to the understanding of speech is considered.
H.D.Parbrook

612.8

4824 THE LOUDNESS OF SOUND IMPULSES OF DIFFERENT DURATION. E.Port.

Frequenz, Vol. 13, No. 8, 242-5 (Aug., 1959). In German.

Describes an investigation of the dependence of the apparent loudness of a sound impulse on the duration of the impulse. The measurements indicate that the range of scatter in such observations is very great. They indicate also an exponential increase of intensity level from −14 to 0 dB. For an increase of impulse duration from 2 to about 100 msec the time constant in this range lies between 15 and 50 msec.
A.B.Wood

612.8

4825 THE RINGING EFFECT IN THE EAR BY INTENSE SOUNDS. E.Schaefer.

Frequenz, Vol. 13, No. 10, 316-23 (Oct., 1959). In German.

Apparatus is described to determine the recovery time of the ear after exposure to intense sounds. The re-adaptation of the ear to normal sensitivity is determined after exposure to sounds of varying intensity and duration. The sounds employed in the investigation are interrupted noise and sounds in frequency-bands extending from 0.1 to 10 kc/sec. Curves are shown which indicate (1) the overload limits of the ear as a function of time of application of the sound, and (2) the rate of re-adaptation of the ear after exposure to various "overloads".
A.B.Wood

612.8

### 4826 MASKING BY OCTAVE BANDS OF NOISE IN NORMAL AND IMPAIRED EARS.

J.F.Jerger, T.W.Tillman and J.L.Peterson.

J. Acoust. Soc. Amer., Vol. 32, No. 3, 385-90 (March, 1960).

The masking of sinusoids by three octave bands of thermal noise was measured in normal and hearing-impaired ears at each of two effective noise levels. For frequencies within the noise bands results were essentially equivalent for all groups studied at either effective level. At frequencies both above and below the noise band no differences among groups were noted at the 10-dB effective level. At the 30-dB effective level, however, both presbycusics and sensorineural losses of presumably cochlear origin showed more masking than either normals, plugged normals, or conductives.

612.8

### 4827 THE MECHANICAL IMPEDANCES OF MASTOIDS OF SOME NORMAL AND DEAF SUBJECTS.

J.Y.Morton and R.A.Jones.

Acustica, Vol. 6, No. 4, 335-8 (1956).

Measurements of the mechanical impedance of mastoids of thirteen normal subjects and three deaf subjects have been made. It is shown that between 400 and 4000 c/s the mastoid behaves approximately as a simple series resonant system, and that there appears to be a significant difference between the mean values of compliance, mass and resistance for normal subjects and those for mastoids which experience the continuous pressure of bone-conduction receivers. Results have also been obtained, showing the dependence of the impedance upon the area and applied force of the measuring surface.

## Vision

612.8

### 4828 A CROSS-CORRELATION PROCESS IN THE NERVOUS CENTER OF AN INSECT EYE. B.Hassenstein.

Nuovo Cimento Suppl., Vol. 13, No. 2, 617-19 (1959).

The effect of stimulating two adjacent ommatidia of an insect eye is studied, and a correlation mechanism that accounts for the facts is proposed. H.N.V.Temperley

612.8

### 4829 MEASUREMENTS OF TEMPORAL ADAPTATION TO SPATIAL DETAIL VISION. A.J.Seyler and Z.L.Budriki

Nature (London), Vol. 184, 1215-17 (Oct. 17, 1959).

Experiments in which the visual detail of a pattern is artificially increased with time show that a given interval is required after the presentation of a persistent display before optimum resolution is achieved. R.A.Weale

612.8

### 4830 AGE DEPENDENCE OF THE PUPILLARY DIAMETER. R.Leinhos.

Optik, Vol. 16, No. 10-11, 669-71 (Oct.-Nov., 1959). In German.

When the eye is dark-adapted the mean pupillary diameter decreases from 8 mm at 16 years to 6.5 mm at 65. There is no significant analogous change when the eye is light-adapted.

R.A.Weale

# TECHNIQUE . MATERIALS

62 : 621-52

### 4831 TWO EMISSION STABILIZERS FOR ELECTRON-BOMBARDMENT FURNACES. D.Allenden.

J. sci. Instrum., Vol. 36, No. 2, 66-70 (Feb., 1959).

Stabilization requirements and techniques for electron-bombardment heating are considered, and basic design formulae are presented for a flexible control system applicable to temperature-limited emission furnaces. Power handling capacity, loop stability and speed of response are discussed, and full circuit details of practical stabilization systems for a 250 W and a 6 kW furnace are given. It is concluded that emission stabilization is always beneficial, and sometimes essential, and that emission stabilities are better than 0.5% at powers up to 20 kW are practicable.

62

### 4832 ULTRA-HIGH-PRESSURE, HIGH-TEMPERATURE APPARATUS: THE "BELT". H.T.Hall.

Rev. sci. Instrum., Vol. 31, No. 2, 125-31 (Feb., 1960).

Equipment is described for maintaining pressures of $10^5$ atm at temperatures in excess of 2000°C for long periods of time. The equipment makes use of conical Carboloy pistons that push into each end of a specially shaped Carboloy chamber. Both chamber and pistons receive lateral support from stressed binding rings. Axial motion of the conical pistons in and out of the chamber is accomplished (while still maintaining a pressure seal) by the use of a specially shaped sandwich gasket made up of naturally occurring pyrophyllite and a steel cone. The arrangement gives a multistaging effect in a single stage. Pyrophyllite in addition to its use in the gasket is also used as pressure transmitting medium, thermal insulation, and electrical insulation. The sample is heated by passage of an electric current through a metal or graphite tube. Methods of pressure and temperature calibration as well as constructional details are discussed.

620.1 : 621.317.44

### 4833 NEW TYPE OF SEARCH COIL FOR METAL-PIPE LOCATION. J.A.Phillips.

J. sci. Instrum., Vol. 36, No. 9, 399-400 (Sept., 1959).

A method of tracing metal pipes, involving the amplification of the voltage induced in a special type of search coil by transient currents injected into the pipe, is described. The search coil consists of two identical flat coils mounted side by side in the same plane, and so connected that the output voltage is equal to the difference of the voltages induced in the two coils. An audible signa is obtained in headphones after amplification of the output voltage. It is found that, with this twin coil system, the signal strength varie approximately as $1/R^2$, where R is the perpendicular distance from the pipe to the search coil, and that a more reliable performance is obtained compared with the usual single type of search coil.

669 : 539.17

### 4834 METALLURGY IN THE DEVELOPMENT OF ATOMIC POWER. J.A.Sabato.

Amer. J. Phys., Vol. 28, No. 3, 228-34 (March, 1960).

Some of the metallurgical problems in the construction of nuclear reactors are discussed. Typical problems resulting from neutron bombardment encountered such as uranium growth, deterior ation of fuel cans, thermal effects, and radiation effects, are presented in detail. Solutions to some of these problems found during the construction of the Calder Hall reactor in the United Kingdom are given as examples of the complex problems encountered. Some of the basic solid-state effects due to neutron irradiation are still not fully understood and are being investigated.

# LIST OF JOURNALS

The following list supplements the List of Journals published with the Index to Volume 62 (1959). Reprints of the List of Journals can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s.0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

| | |
|---|---|
| Automat. Elect. tech. J. | Automatic Electric Technical Journal (Formerly: General Telephone Technical Journal [Gen. Teleph. tech. J.]).<br>Automatic Electric Laboratories Inc., Northlake, Illinois. |
| B.B.C. Nachr. | B.B.C. Nachrichten<br>Brown, Boveri und Çie, Mannheim. |
| Trav. Inst. Sci. Chérifien Ser. Sci. phys. | Travaux de l'Institut Scientifique Chérifien, Série Sciences Physiques.<br>Société des Sciences Naturelles et Physiques du Maroc, Rabat.<br>Publishers: Gauthier-Villars, 55 Quai des Grands-Augustins, Paris. |

NEW JOURNAL

| | |
|---|---|
| J. math. Phys. (New York) | Journal of Mathematical Physics<br>American Institute of Physics, 335 East 45th Street, New York 17, N.Y.<br>Vol. 1, No. 1, dated January-February, 1960. Bi-monthly. |

CHANGE OF TITLE

| | |
|---|---|
| Gen. Teleph. tech. J. | General Telephone Technical Journal<br>Title changed to: Automatic Electric Technical Journal [Automat. Elect. tech. J.] with issue dated February, 1960. |

NOTE

The journal formerly quoted as "J. Math. and Phys." is now referenced as "J. Math. and Phys. (Cambridge, U.S.A.)".

# ERRATA

Abstr. 2840 (1960) line 4: for "655-7" read "635-7".
line 6: for "Block" read "Bloch".
Abstr. 3474 (1960) line 3: for "Vol. 65" read "Vol. 45".

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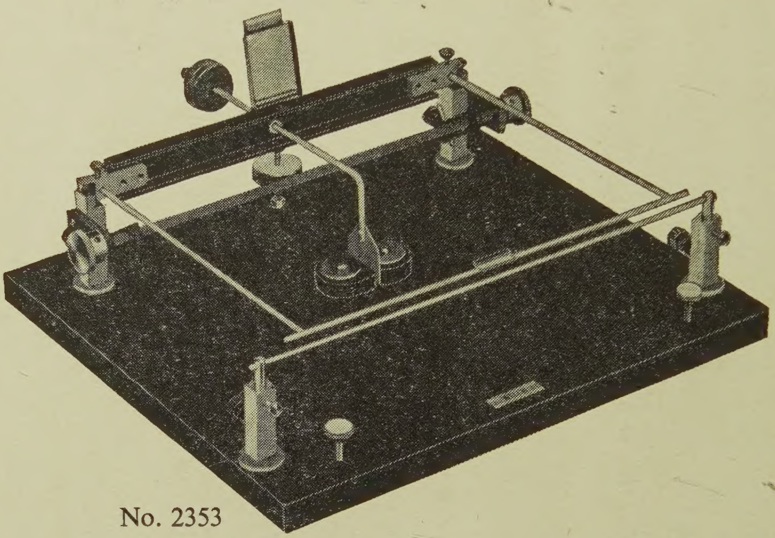

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